CENTRAL VALLEY FISH AND WILDLIFE MANAGEMENT STUDY

Coleman National Fish Hatchery and Keswick Fish Trap Operations

THIS REPORT WAS PREPARED PURSUANT TO FEDERAL RECLAMATION LAWS (ACT OF JUNE 17, 1902, 32 STAT. 388 AND ACTS AMENDATORY THEREOF OR SUPPLEMENTARY THERETO). PUBLICATION OF THE FINDINGS AND CONCLUSIONS HEREIN SHOULD NOT BE CONSTRUED AS REPRESENTING EITHER THE APPROVAL OR DISAPPROVAL OF THE SECRETARY OF THE INTERIOR. THE PURPOSE OF THIS REPORT IS TO PROVIDE INFORMATION AND ALTERNATIVES FOR FURTHER CONSIDERATION BY THE BUREAU OF RECLAMATION, THE SECRETARY OF THE INTERIOR, AND OTHERS.

SPECIAL REPORT

NOVEMBER 1985

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MID-PACIFIC REGION • SACRAMENTO, CALIFORNIA

SUMMARY

This report reviews the operational status of Coleman National Fish Hatchery (NFH) and Keswick Fish Trap. The Coleman NFH and Keswick Fish Trap are operated to augment anadromous fish runs of the upper Sacramento River. Hatchery brood stock is obtained from fish ascending Battle Creek and fish trapped at Keswick Dam.

Fish production at Coleman NFH has been appreciably increased by improvement and expansion of facilities. Chinook salmon and steelhead trout runs in the upper Sacramento River system, however, have declined in recent years. In some years, numbers of broodfish returning to Coleman NFH and Keswick Fish Trap have not been sufficient to meet egg quotas.

The basic problems at the Coleman NFH are:

1. Inadequate water supply.
2. High energy operating costs.
3. Insufficient rearing and holding space for salmon.
4. Deterioration of water supply systems, food storage facilities, emergency power generation equipment and water heating/cooling facilities.
5. Fish losses due to disease.
6. Insufficient knowledge on optimum release sites, timing and size of releases.
7. Inadequate water quality for hatchery production.
8. Inadequate pollution abatement facilities.

Future developments which may present additional problems at Coleman NFH include:

1. Increased operating expenses resulting from higher energy costs.
2. Proposed hydroelectric powerplants at Red Bluff Diversion Dam and Anderson-Cottonwood Irrigation District Diversion Dam, which may further impact migration and survival of hatchery fish.

3. Increased commercial and sport fishing effort on hatchery stocks.

4. Sacramento-San Joaquin Delta water facilities and further water project development.

Five basic problems at the Keswick Fish Trap are:

1. Ineffectiveness of the trap facilities at flows exceeding 16,000 ft^3/s.

2. Insufficient attraction flow into the fishway.

3. Occasional fishkills in the trap facility from acid mine waste discharge or sustained high discharge.

4. Inadequate fish passage facilities at Anderson-Cottonwood Irrigation District Diversion Dam prevent salmon from arriving at the Fish Trap.

5. Fish losses due to entrapment in the spillway basin adjacent to the trap facility.

Future developments which may further impact operation of the Keswick Fish Trap include proposed hydroelectric projects for the Red Bluff and Anderson-Cottonwood Irrigation District Diversion Dams and a new Keswick Dam.

Measures which should be taken to counteract the problems at Coleman NFH include:

1. Revise the 1948 Memorandum of Agreement.

2. Obtain Central Valley Project project-use electrical power rates for Coleman NFH operations.

3. Rehabilitate existing and develop new water sources.

4. Rehabilitate the existing diversion dams and fishway in Battle Creek.

5. Rehabilitate hatchery building, water supply intakes and water supply valves; construct new brood stock holding and spawning facilities and juvenile prerelease ponds.

6. Replace fish food storage facility, rehabilitate roads, parking areas and miscellaneous buildings, improve visitor facilities and construct fish protection structures.

7. Expand pollution abatement facilities.

8. Investigate the potential for developing hydroelectric power generation from hatchery discharge into Battle Creek.

9. Conduct evaluation studies to improve propagation techniques and develop measures to maximize smolt survival and adult returns to the fisheries and hatchery.

Measures which should be taken to counteract these problems at the Keswick Fish Trap include:

1. Augment fishway releases.

2. Improve communication and coordination between Fish and Wildlife Service (Coleman NFH) and Bureau of Reclamation (Shasta-Keswick Operations staff).

3. Modify the trap control system.

4. Reassess the potential for increasing operational capability of the fish trap at flows greater than 16,000 ft^3/s.

TABLE OF CONTENTS

Contents (continued)

LIST OF TABLES

LIST OF FIGURES

APPENDICES

PART I

INTRODUCTION

Coleman National Fish Hatchery (NFH), and Keswick Fish Trap were constructed by the Bureau of Reclamation (BOR) as part of the Salmon Salvage plan to mitigate fish losses due to construction and operation of Shasta and Keswick Dams of the Federal Central Valley Project (CVP). Coleman NFH is also operated for the investigation, protection, improvement, and conservation of fish in the Sacramento River Basin. Chinook salmon and steelhead trout are the only fish presently propagated at the hatchery.

PURPOSE AND OBJECTIVE

The purpose of this report is to appraise the operational status of the Coleman NFH and Keswick Fish Trap. Past and present production capability, operational problems, and evaluation studies are reviewed in order to determine the need for additional support for the ongoing evaluations of Coleman NFH and Fish Trap operations. The report utilized existing data; no new data were developed.

The objective of this report is to contribute to the effort at Coleman NFH to maximize the hatchery's contribution to the anadromous fisheries of California and the Pacific Northwest.

RELATED PROGRAMS

Current studies at the Coleman NFH include programs to improve propagation techniques and develop measures to maximize smolt survival and adult returns to the fisheries and hatchery. These studies are designed to provide improved disease control and brood stock genetic quality, and further identify differential survival and contribution of salmon and steelhead trout released at various sizes, locations, and times.

A proposal to develop new methods of control of Infectious Hematopoietic Necrosis (IHN) virus at Coleman NFH has been initiated involving a 10-year program to span two generations of chinook salmon from the same brood year (U.S. Fish and Wildlife Service, 1979b). The program is a cooperative (FWS) effort by the Seattle National Fishery Research Center, the Coleman NFH, and the Tehama-Colusa Fish Facility. The results from this study should enable hatchery staff to predict the occurrence of high disease incident. Timely preventative measures could be taken to reduce mortality. The objective is total control of the disease.

The U.S. Fish and Wildlife Service (FWS) developed a study plan to determine the effects of geographical transfer and of selective breeding on survival of juvenile steelhead trout released from Coleman NFH (U.S. Fish and Wildlife Service, 1981). This study will test the hypothesis that Coleman steelhead have low survival rates because of spawning size selection and interbreeding with other strains of steelhead trout and Kamloops rainbow trout. Groups of steelhead trout will be compared from adult hatchery fish selected for large size, adult hatchery fish of all sizes, and adult hatchery females and wild males (Dave Vogel, U.S. Fish and Wildlife Service, Fishery Assistance Office, Red Bluff, pers. comm.). They will be reared similarly at Coleman NFH and marked, released, and recaptured to determine survival. If man-induced genetic changes are shown to reduce survival, guidelines will be generated to increase efficiency of hatchery programs.

The California Department of Fish and Game (DFG) is continuing a long-term study initiated in 1976 to assess the contribution of late fall-run chinook salmon trapped at Keswick Dam and propagated at Coleman NFH. Marked late fall-run chinook salmon were released from Coleman in the fall (October and November) from brood years 1975, 1976, and 1978, and in the winter (January) from brood years 1977 through 1981 (Dick Hallock, California Department of Fish and Game, (retired) pers. comm.). This study will not be completed until adult returns have been analyzed.

The DFG, in cooperation with FWS, initiated a new study at Coleman NFH in 1981 by marking and releasing 300,000 fall chinook in groups of 100,000 each at Battle Creek, in the Sacramento River downstream from the Red Bluff Diversion Dam (RBDD), and at Knights Landing. The objective is to find a release site that will increase survival (and thus fishery returns) and at the same time insure sufficient hatchery returns to continue the hatchery production goals. Salmon will be marked and released at these sites through 1984 and returns to the fishery and spawning runs will be analyzed to determine survival rates.

The FWS proposed in 1979 that a 10-year study be funded to compare return rates to the fisheries and to the Coleman NFH of marked groups of salmon and steelhead released from the hatchery at different times of the year. The objective of this study is to increase survival of fish released at Coleman NFH by identifying optimum fish size and favorable release periods. The study will also compare the cost per adult harvested or returning to the hatchery. Hatchery-produced fish were marked and released in the dual purpose spawning channel of the Tehama-Colusa Canal Fish Facilities. Additional activities include releasing marked fish directly into Battle Creek and the Sacramento River and sampling juvenile populations with trawls, fyke nets, seines, and other fish collecting equipment (U.S. Fish and Wildlife Service, 1981).

No studies have been conducted or are proposed which would identify impacts or improve operations at the Keswick Fish Trap. The facility is essentially operating within its designed capability. Late fall-run chinook salmon presently trapped at Keswick and propagated at Coleman NFH are being marked with coded wire tags in order to determine favorable release size, timing of release, and contribution to the fishery and escapement (R. Hallock, California Department of Fish and Game, (retired) pers. comm.).

Future developments which may further impact operation of the Keswick Fish Trap include potential expansion of the existing BOR hydroelectric facilities, the proposed Lake Redding Hydropower Project, and Enlarged Shasta Project. The latter would involve constructing a new Keswick Dam several miles downstream from the existing structure.

Ongoing and proposed studies recommended by the FWS, in cooperation with DFG, include the following evaluations (not necessarily in order of importance) (U.S. Fish and Wildlife Service, 1981):

Ongoing

1. Determine optimum release site for Coleman NFH steelhead trout. Estimated total cost is $140,000 over an 8-year period.
2. Determine optimum time, site, and size for release of Coleman NFH chinook salmon and steelhead trout. Estimated cost is $580,000 over a 10-year period.
3. Determine effect of stock transfer and selective breeding on survival of juvenile steelhead trout produced at Coleman NFH. Estimated cost is $184,000 for an 8-year period.

Proposed

1. Evaluate adult steelhead harvest in the upper Sacramento River to determine if hatchery stocks are being overharvested. Estimated cost is $370,000 over a 4-year period.
2. Evaluate contribution of salmon produced at Coleman NFH to the fisheries and their returns to propagation facilities. Estimated study cost is approximately $450,000 over a 10-year period.

ACKNOWLEDGMENTS

This report was initially prepared for the BOR by the Sacramento Field Office, Ecological Services Division, FWS. Final revisions to the report were made by BOR. The staffs of BOR, FWS, DFG, California Department of Water Resources (DWR), and National Marine Fisheries Service (NMFS) reviewed and provided comments on the various drafts.

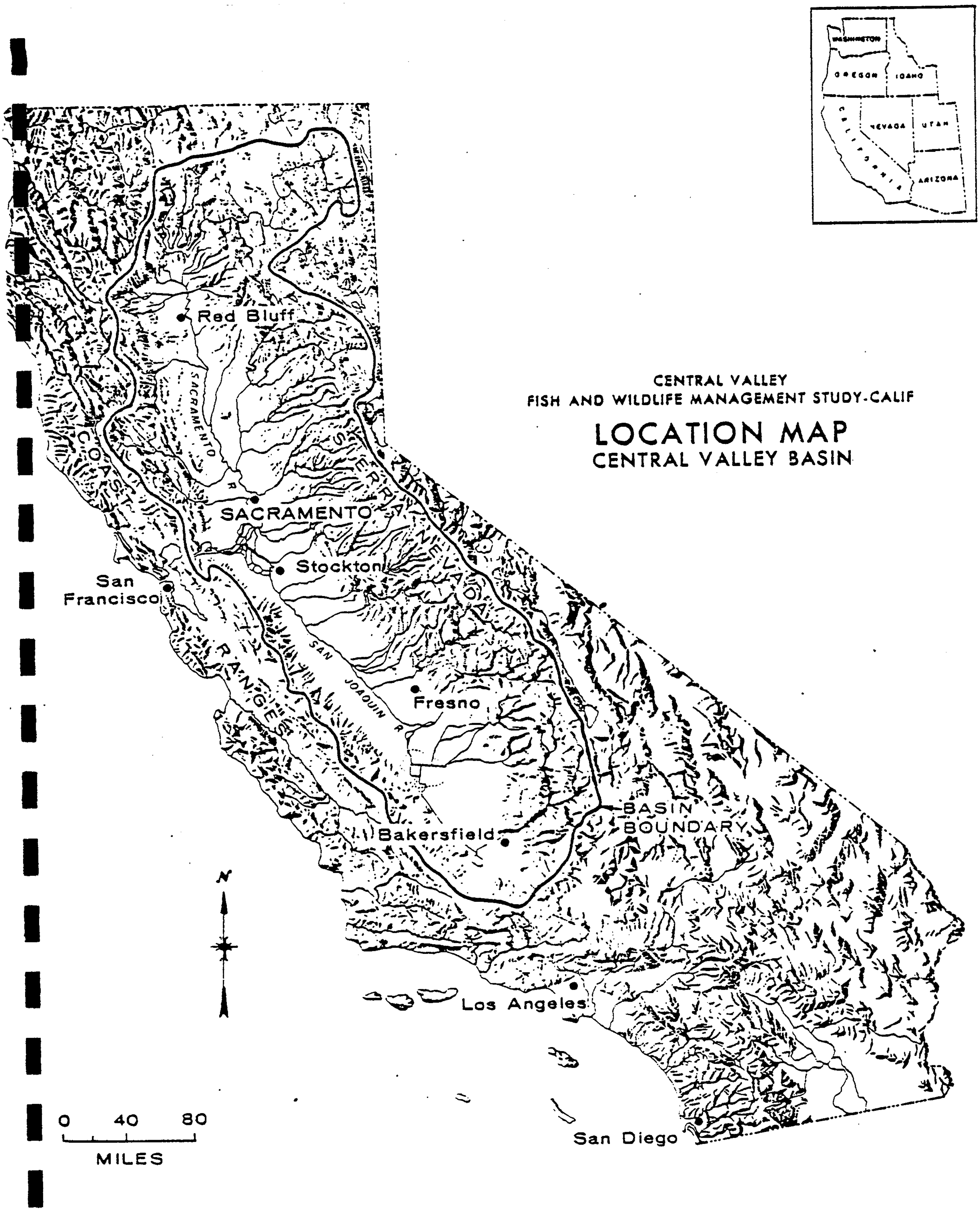
RELATIONSHIP TO CENTRAL VALLEY FISH AND WILDLIFE MANAGEMENT STUDY

This report is one of a series planned for the Central Valley Fish and Wildlife Management Study (CVFWMS). The study area, shown on figure 1, is the Central Valley hydrologic basin. Objectives of the study are to:

1. Identify fish and wildlife problems and opportunities associated with water resource development, distribution, and utilization in the Central Valley.
2. Provide the basis for formulating and recommending a long-range management framework within which fish and wildlife resources can be protected and enhanced.

The overall study, initiated in fiscal year 1979, is being made to formulate a comprehensive framework of fish and wildlife management guidelines for the Central Valley that will be useful to Federal and State agencies. A comprehensive approach is essential to resolve the very complex and controversial water-related fish and wildlife issues.

Water resource development and utilization within the valley are so interrelated that localized modifications of water and land and of fish and wildlife management practices often result in corresponding impacts elsewhere in the valley. Any actions such as modernization of fish hatcheries, streamflow alterations, and modification of control structures cannot be pursued effectively without knowledge of the positive and negative impacts on beneficial uses throughout the system. The comprehensive study of existing basinwide baseline conditions is being made so that the impacts of proposals to resolve existing fish and wildlife



CENTRAL VALLEY
FISH AND WILDLIFE MANAGEMENT STUDY-CALIF

LOCATION MAP
CENTRAL VALLEY BASIN

FIGURE 1

C-044258

problems or the development of new water supplies can be evaluated adequately.

Three categories of problems and opportunities are being addressed in the overall study. They are: anadromous fish, wildlife, and reservoirs and miscellaneous. This report, one of a series in the category titled anadromous fish, is identified as problem A-6, in table 1, which lists the problems for that category.

BASIN DESCRIPTION

The area covered by the CVFWMS includes two major river basins, the Sacramento on the north and the San Joaquin on the south. The combined basin is nearly 500 miles long and 120 miles wide. It contains 38 million acres of land, or more than one-third of the area of California. Nearly one-third of the basin area is valley floor, where the bulk of the population, industry, and agriculture is located. The foothills and mountains in the two-thirds of the basin surrounding the valley floor receive most of the precipitation and provide the main source of the water supply for the valley. The summers are hot and usually rainless.

Most of the precipitation occurs in the winter. The water supply of the Central Valley is derived chiefly from snowmelt from the Sierra Nevada to the east, with minor amounts of runoff from the Coast Range mountains to the west, and from precipitation on the valley floor.

Runoff varies widely from year to year and from season to season, being highest in the winter and spring, and low in the summer and fall months. Many streams in the area are intermittent, with flow only during wet periods of the year.

Table 1. Anadromous fish problems assigned to Plan Formulation Team A

Problem No.	Description
A-1	Determine the flows required in the upper Sacramento River to provide for all freshwater life stages of salmon at various population levels.
A-2	Determine whether fish passage at Red Bluff Diversion Dam is a problem and, if so, formulate a solution.
A-3	Evaluate the disturbance that operation of ACID's dam at Redding may have on salmon spawning and egg incubation and its significance to all affected fish populations and formulate possible solutions to problems if needed.
A-4	Evaluate the status of Tehama-Colusa Canal Fish facilities, including screens to canal intake, and develop recommendations for resolving problems and making improvements.
A-5	Investigate the status of the salmon spawning habitat in the upper Sacramento River and develop recommendations for resolving problems and making improvements.
A-6	Determine the need for additional support for ongoing evaluation of Coleman National Fish Hatchery and Keswick Fish Trap operations, and provide this support if necessary.
A-7	Evaluate the potential of a comprehensive restoration program for San Joaquin salmon and identify the actions required to accomplish this.
A-8	Evaluate the need for fishscreens on diversion facilities along the Sacramento River.
A-9	Evaluate the disturbance that operation of Red Bluff Diversion Dam may have on salmon spawning and egg incubation and evaluate its significance to all affected fish populations, and formulate corrective measures if needed.
A-10	Determine whether predation of anadromous fish in the upper Sacramento River is a problem and, if so, formulate a solution.
A-11	Evaluate the potential for improving the production of anadromous fish in tributaries to the Sacramento River.
A-12	Investigate need and potential of enlarging Nimbus Fish Hatchery.

Water development in the basin spans a period of more than 120 years. Basically, it progressed through four stages. In the first stage, local diversions were made directly from the rivers. The second stage was the widespread use of ground-water pumping adjacent to rivers. In the third, water was stored for use within a river basin. In all of these stages, the water facilities were constructed and operated by individuals, companies, districts, or other water service organizations.

Large-scale Federal water development in the Central Valley began in 1935 with the initial phases of construction of the CVP by the BOR. This inaugurated the fourth stage and marked the beginning of coordinated interbasin water development in the Central Valley. In 1961, construction began on the California State Water Project, including joint Federal-State facilities. The primary source of water for the two projects is the Sacramento River Basin, although some water is derived from the San Joaquin Valley to the south, and some is imported from the Trinity River to the west.

The CVP is a series of storage facilities, conveyance systems, and powerplants constructed, under construction, or proposed, to make multipurpose use of the water supplies that can be controlled by the facilities. The project reservoirs are coordinated in their operation to make maximum use of the available water supply.

STUDY AREA

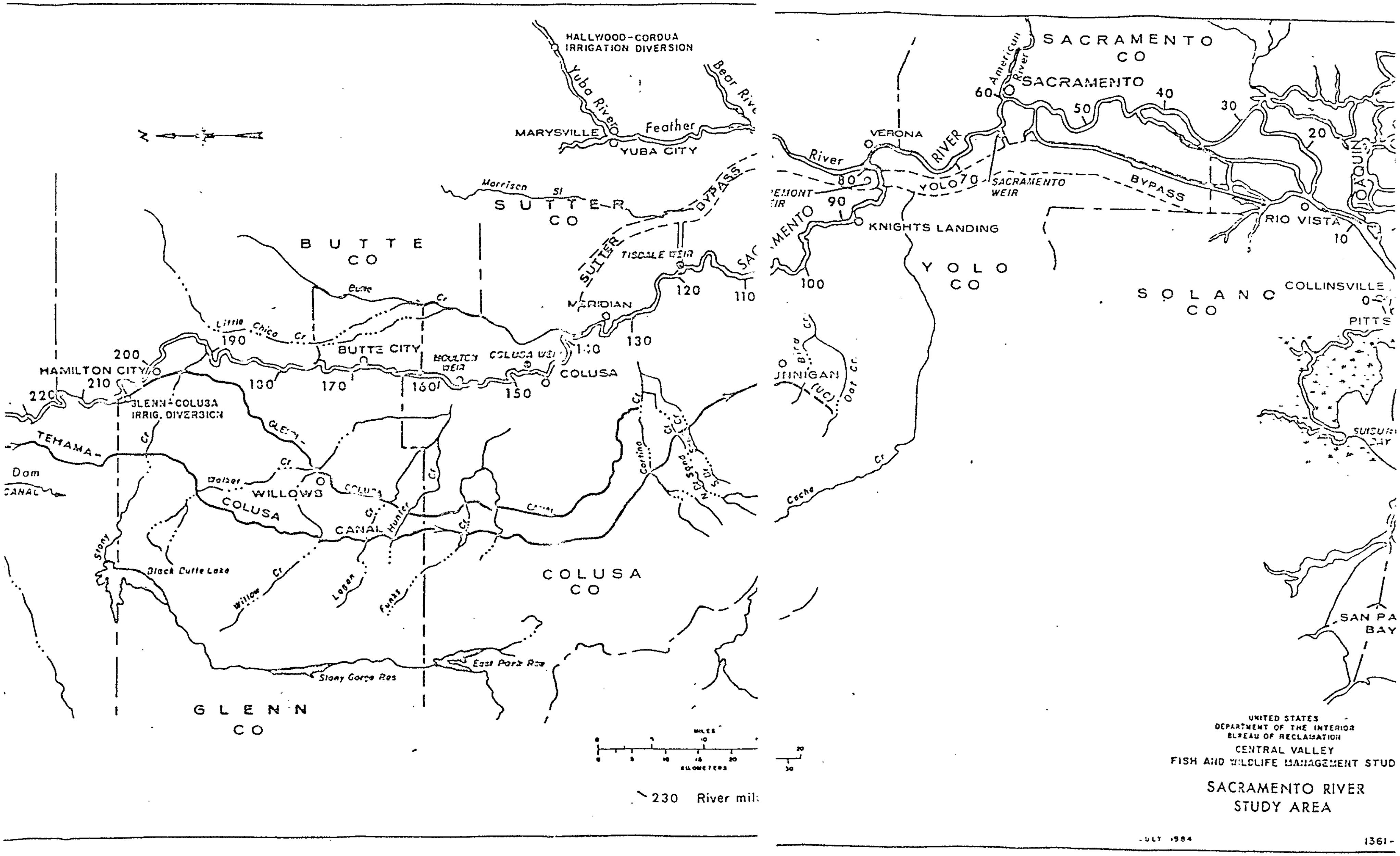
The study area for this report includes virtually the entire length of the Sacramento River from Keswick Dam downstream to the Pacific Ocean. The primary focus, however, is on the immediate vicinity of the Coleman NFH and Keswick Dam facilities.

The Sacramento River drains the northern portion of California's Central Valley, flowing southward, to converge with the San Joaquin River at the western edge of the Sacramento-San Joaquin Delta (figure 2). From there commingled flows continue toward the ocean through Suisun and San Pablo Bays to San Francisco Bay some 430 miles from the Sacramento River's point of origin. The main stem of the Sacramento River provides about 300 miles of salmon habitat.

From the standpoint of both water supply and fishery resource, the Sacramento River upstream from its confluence with the Feather River historically has been the most important reach of the river system. This reach, termed the "Upper Sacramento," is the portion of the river where spawning occurs.

The lower Sacramento River includes the main stem from the mouth of the Feather River (river mile 80) downstream to the confluence with the San Joaquin River at Collinsville (river mile 0, figure 2). There is no spawning in the lower portion, but main tributaries to the lower Sacramento River--the American and the Feather Rivers and the Yuba River tributary to the Feather River--are major spawning areas.

The FWS prepared a report on Coleman NFH and Keswick Fish Trap for use in the CVFWMS. The report consists of an analysis of the operations and problems at the two facilities plus two appendices: appendix A, the 1948 Memorandum of Agreement between the Bureau of Reclamation and the Fish and Wildlife Service; and appendix B, Battle Creek Stream Flow Data.


HALLWOOD-CORDUA
IRRIGATION DIVERSION
Yuba River
Bear River
MARYSVILLE
Feather
YUBA CITY
Morrison Sl
SUTTER
CO
BUTTE
CO
SUTTER BYPASS
TISDALE WEIR
MERIDIAN
Butte Cr
Little Chico Cr
BUTTE CITY
MOULTON WEIR
COLUSA WEIR
COLUSA
HAMILTON CITY
GLENN-COLUSA
IRRIG. DIVERSION
TEHAMA
Dam
CANAL
WILLOWS
COLUSA CANAL
Black Butte Lake
Stony Gorge Res
East Park Res
COLUSA
CO
GLENN
CO
SACRAMENTO
CO
SACRAMENTO
American River
VERONA
RIVER
YOLO
SACRAMENTO WEIR
BYPASS
KNIGHTS LANDING
RIO VISTA
YOLO
CO
SOLANO
CO
COLLINSVILLE
PITTS
SUISUN BAY
SAN PA
BAY
Cache Cr
MILES
KILOMETERS
230 River mil
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY
FISH AND WILDLIFE MANAGEMENT STUD
SACRAMENTO RIVER
STUDY AREA
JULY 1984
1361-
FIG

LOCATION OF FACILITIES

Coleman NFH is located in Shasta County, California, on a relatively flat parcel of land on the north bank of Battle Creek approximately 3 miles east of the Sacramento River and 17 miles southeast of the city of Redding. Ground elevations within the hatchery property vary from a low of approximately 405 feet mean sea level (m.s.l.) in the creekbed at the west boundary to a high of approximately 480 feet m.s.l. along the north property line. Elevations within the existing hatchery building and rearing pond area vary from 445 feet m.s.l. to 415 feet m.s.l.

To the north and south of the hatchery lie the rolling foothills of the Cascade Range with peaks ranging from approximately 1,000 to 2,700 feet m.s.l. Small valleys and sharp breaks in the land are produced by numerous seasonal streams draining the area. Battle Creek flows through a valley from the east to the west along the southern edge of the hatchery property.

Coleman NFH is funded and operated by FWS. Presently, the hatchery consists of 75.41 acres of land owned by the FWS and various easements for pipelines and access.

Keswick Fish Trap is located at the base of Keswick Dam on the Sacramento River, approximately 9 miles downstream from Shasta Dam in Shasta County, California. The trap is owned and maintained by the BOR and is operated by FWS in conjunction with Coleman NFH, located about 25 miles southeast of Keswick Dam (figure 2).

HISTORY/BACKGROUND

The Coleman NFH and Keswick Fish Trap were constructed in 1942 as part of the mitigation measures to help preserve significant runs of chinook salmon threatened by the loss of natural spawning areas resulting from the construction and operation of Shasta Dam and Keswick Dam on the Sacramento River. The BOR constructed the hatchery and Keswick Fish Trap and funded the hatchery operation until 1949 (appendix A). The CVP was authorized and established under the provisions of the Emergency Relief Appropriation Act of 1935 (49 Stat. 115) and the First Deficiency Appropriation Act, Fiscal Year 1936 (49 Stat. 1622). The River and Harbor Act of 1937 (50 Stat. 844, 850) reauthorized the CVP for construction by the Secretary of the Interior subject to the Reclamation laws, and with due regard for wildlife conservation. Total cost for Coleman NFH and Keswick Fish Trap was $2,013,750.

Four salvage plans were proposed by the FWS for salvaging the runs of Sacramento River salmon blocked by Shasta Dam. A board of consultants (appointed by the BOR) recommended one of these plans called the "Sacramento River, Battle Creek, Deer Creek Plan" which the BOR accepted. Objectives of the plan were to ensure proper distribution of salmon in the river for natural spawning, reduce spring-run chinook losses in the main river due to high water temperatures while Shasta Lake filled, release young salmon from hatcheries in accord with the natural migration period, and continue studies of artificial propagation.

It was anticipated that the upstream migrating adult fall-run chinook could be held in the main Sacramento River by racks to encourage natural spawning. Excess fish would be trapped and taken to the hatchery facilities on Battle Creek. Spring-run chinook would be trapped and transferred to suitable tributaries for natural spawning such as Deer Creek, and to Battle Creek for artificial propagation at the Coleman NFH. The selected plan included the following annual objectives:

1. Transfer of 10,000 spring-run chinook salmon to Deer Creek for natural propagation.
2. Transfer of 2,000 spring-run chinook salmon to Battle Creek for artificial propagation.
3. Transfer of 18,000 summer- and early fall-run chinook salmon to Battle Creek for artificial propagation.
4. Distribution of 30,000 fall-run chinook salmon in the Sacramento River by installing three racks to control migration.

To carry out this plan, the BOR agreed to provide the following:

1. A fish ladder, trap and lift at Keswick Dam and at Balls Ferry rack.
2. Seven 1,000-gallon capacity fish tank trucks.
3. A hatchery on Battle Creek with the capacity for 58 million eggs or advanced fry, and 29 million fingerlings, and appurtenant ponds, cold storage facilities and buildings.
4. Five racks in Battle Creek to form four holding and ripening pools for adult spring-run chinook salmon transferred from the Sacramento River.
5. Three racks across the Sacramento River.
6. A fishway around the lower falls on Deer Creek to make accessible an additional 5 miles of spawning gravel.

Two hatcheries on Battle Creek participated in these operations. These were the old Battle Creek Hatchery near the mouth of Battle Creek which was closed after the 1944 season, and Coleman NFH located approximately 6 miles upstream from the Sacramento River which began operation in 1943.

All the agreed upon plans were not carried out for various reasons, and the salvage goals were only partially realized. Only two racks were installed in the Sacramento River, and these failed to function properly. The total salmon population allowed to spawn in the river between Balls Ferry and Keswick Dam was much greater than planned. Mortality of spring-run chinook transferred to Deer Creek was high and the ultimate success of this operation appeared quite dubious. Mortality of adult spring-run chinook salmon transferred to Battle Creek was also high, primarily because of excessively warm water temperatures. Propagation of spring-run chinook salmon at Coleman NFH was subsequently suspended.

By 1946, none of the racks in the Sacramento River were operating and trapping of spring-run chinook at Keswick had ceased. Hatchery operations at the Coleman Station were considered successful except for the problem of holding adult spring-run chinook until ready for spawning. It was concluded that the spring-run of salmon was more likely to be perpetuated if left undisturbed in the Sacramento River as environmental conditions (temperature and flow) below Shasta Dam were satisfactory.

Presently, the only remaining federally operated elements of the Shasta Salmon Maintenance Plan are the Coleman Hatchery and the Keswick Fish Trap. In 1948 a Memorandum of Agreement was signed between the BOR and the FWS pertaining to the custody and future operation of the Coleman NFH and other fishery maintenance facilities of the upper Sacramento River, including Keswick Fish Trap (appendix A). Since July 1, 1949, the FWS has assumed all annual operation, maintenance, and replacement costs at the Coleman NFH. The Keswick Fish Trap is operated by FWS and is maintained by BOR in conjunction with other facilities at Keswick Dam in accordance with a 1951 Memorandum of Agreement.

The 1948 Memorandum of Agreement, which transferred Coleman's operation, maintenance and rehabilitation funding from BOR to FWS, was based on the following premises:

1. That the BOR had constructed Coleman NFH for protection and preservation of migratory fish which spawned in the upper Sacramento River Basin prior to construction of Shasta Dam.
2. The FWS had operated the hatchery facilities since their construction.
3. The BOR and FWS agreed that, as a result of the salmon maintenance plan and operation of Shasta Dam with regard for the welfare of the fishery, the runs above Shasta Dam appeared to have become established below the dam in numbers equal to the numbers existing before the dam was built.
4. There was a need for further fisheries investigation, protection, improvement, and conservation in the Sacramento River Basin.
5. The continued maintenance of Sacramento River salmon runs was recognized as one of the purposes of the CVP in operating Shasta Dam.

6. The continuous release of minimum fish flows (2,500 ft^3/s) and favorable water temperature (between 50 °F and 65 °F) was best suited to maintain the Sacramento River fishery.

This agreement, while recognizing that salmon were successfully spawning in the Sacramento River downstream from the Shasta Dam, should not be construed as a concession on behalf of FWS that BOR has satisfied its mitigation obligation for the Shasta Dam Project. Moffett (1949) concluded in his evaluation of the Shasta Salmon Maintenance Plan that environmental conditions in the river below Shasta Dam were greatly improved for natural production of salmonids, and that these conditions compensated, as nearly as could be determined, for the loss of spawning grounds above Shasta Dam. However, he further concluded that experience was insufficient to definitely establish the success or failure of the salmon maintenance plan and that observations and studies needed to be continued.

Although the goals of the Shasta Salmon Maintenance Plan have only been partially met (i.e., to restore salmon runs to population levels that existed prior to construction of Shasta Dam by BOR), the FWS retains sole responsibility for the operation and maintenance of Coleman NFH.

LIFE HISTORY INFORMATION

Chinook Salmon

There are four distinct spawning populations (commonly referred to as races or runs) of chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento River system. Each run has a unique migrating pattern, thereby perpetuating the existence of separate runs. These runs are named for the time of year the adults ascend the river - spring, fall, late fall, and winter. Following spawning, the adult chinook salmon dies.

Spring-run salmon enter the river system between March and June, spawning from late August through early October with the peak being in September. Downstream migration of the smolts begins in December, peaks in January and February and is complete by the end of April.

Fall-run salmon, the largest run in numbers of fish, migrate into the Sacramento River from September through November and spawn from early October through December. The young migrate downstream from February through early June.

The late fall-run migrate upstream from early November through February and spawn from January through March. Young begin migrating downstream in April. Many late fall chinook salmon reside in the Upper Sacramento River and migrate to sea the following fall.

Winter-run salmon enter the Sacramento River from early January through mid-June. Spawning usually occurs between mid-April and mid-July. Downstream migration of the young occurs between November and February.

Steelhead Trout

The steelhead (Salmo gairdneri) is a subspecies of rainbow trout. The great majority of steelhead are known as fall-run or winter-run steelhead. Fish of this type enter the stream and spawn during the same season. The time of migration varies. If the river is large enough and cool enough, the steelhead may enter in the late summer or early fall.

Whether steelhead start upstream in August or in January, the spawning run usually continues until March or April.

Spawning resembles that of the salmon. Young steelhead usually migrate to the ocean after spending two seasons in freshwater. Faster growing fish migrate after one season, but slow growers may spend up to four seasons in freshwater.

After reaching saltwater, steelhead grow quickly and usually return to spawn in their home streams after one or two seasons. Unlike salmon, steelhead do not necessarily die after spawning. The rigors of migration and spawning do cause many deaths, but fish that have spawned two or three times are not uncommon.

PART II

COLEMAN NATIONAL FISH HATCHERY

OPERATIONAL HISTORY

The Coleman NFH (figure 3) was referred to as the Coleman Station when first placed in operation by FWS in 1943. The station consisted of a main hatchery building containing 288 deep troughs, 28 outdoor rearing and holding ponds, a cold storage and ice plant, a combination garage, shop, and warehouse, and residences for operating personnel. Approximately 55 ft^3/s of good quality water was supplied to the hatchery and rearing ponds by intake lines from the Coleman Powerplant and Battle Creek leading to an open delivery ditch and hatchery intake system. Designed production capacity was 58 million salmon eggs or advanced fry and 29 million fingerlings (Needham, et al., 1943). The total cost for construction, operating, and maintaining all of the migratory fish facilities through June 30, 1949, when operating and maintenance costs were transferred to FWS, was $2,824,000 (Fish and Wildlife Service, Coleman National Fish Hatchery Annual Report, 1975). The present operating budget of the Coleman NFH is approximately $600,000 annually.

Coleman NFH is the only Federal fish hatchery in California (excluding the Tehama-Colusa Canal Fish Facility in Red Bluff) and is one of the largest chinook salmon propagation facilities in the Nation. The Federal Government has constructed other hatcheries in California (i.e., Nimbus, Trinity, and Warm Springs), but these are presently operated by the State and funded by the Federal Government.

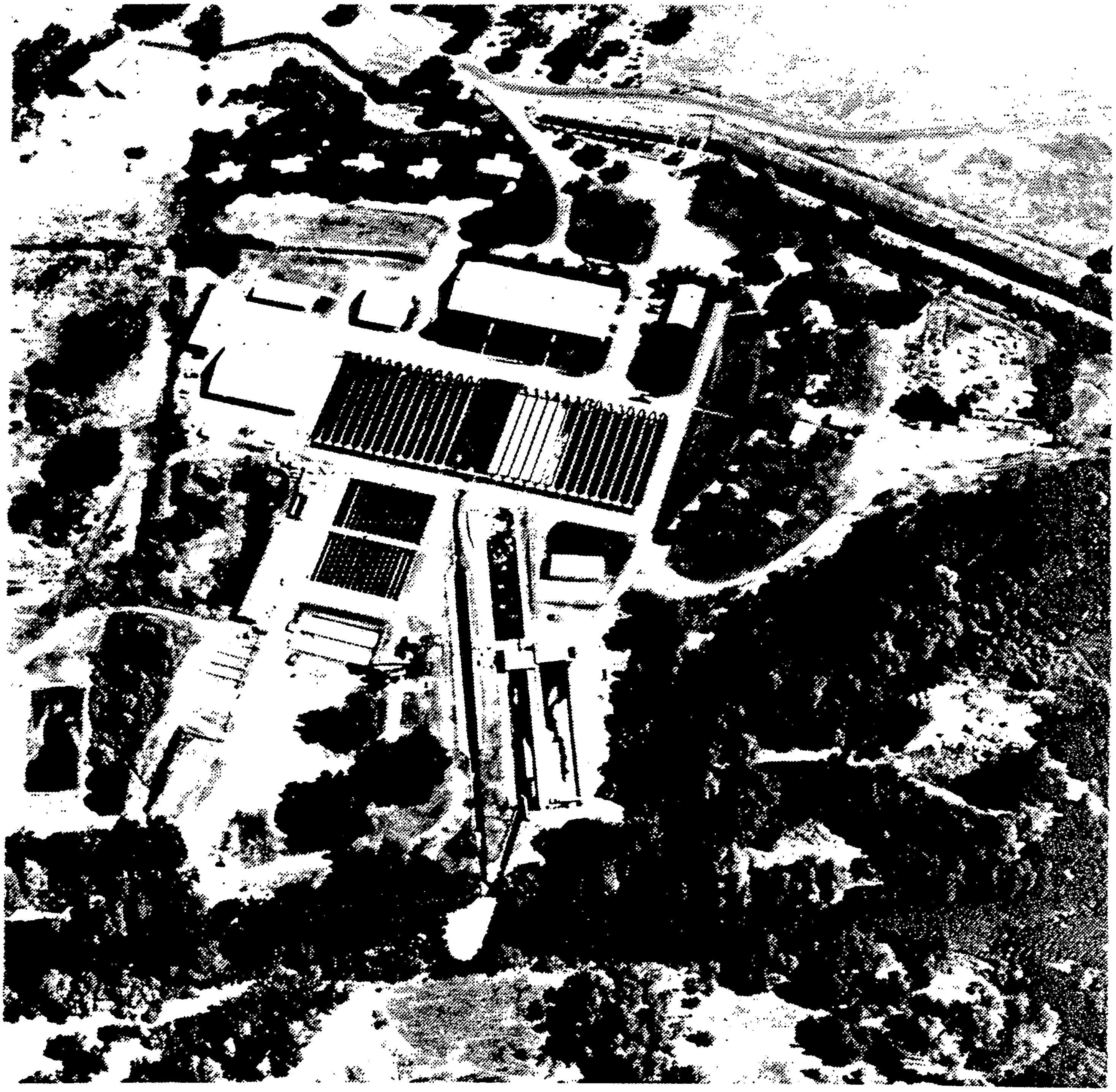


Figure 3. Coleman National Fish Hatchery.

Fall and late fall-run chinook salmon, steelhead rainbow trout, and Kamloops rainbow trout are the primary species of fish which have been artificially propagated at Coleman NFH. Other species, or races, that have been occasionally propagated at the hatchery include winter and spring-run chinook salmon, coho salmon, kokanee salmon, rainbow trout, and brown trout.

Early hatchery production objectives were not specifically defined due to the uncertainty of the salmon maintenance work and the need to develop successful propagation techniques. Juvenile salmon produced in the hatchery were held until they had been feeding for some time and then released into Battle Creek before April 15. The objective was to coincide downstream migration of hatchery fish with natural migration in Battle Creek and the Sacramento River, and to reduce loss of juveniles in irrigation diversions during the spring. Some experimental lots were held and released in the fall after October 15 when irrigation diversions ceased.

The original chinook salmon brood stock for Coleman NFH was obtained from native Battle Creek fish and from fish trapped and transferred from fish traps at the Balls Ferry rack and Keswick Dam. From 1946 through 1949, brood stock came from adult salmon returning to the hatchery to spawn. These fish were held in Battle Creek by racks until mature. From 1950 to date, brood stock have been obtained from both Battle Creek and Keswick Fish Trap. In addition, the Coleman NFH has received surplus salmon and steelhead eggs from various State hatcheries including Nimbus, Feather River, and Mad River Hatcheries.

Considerable improvements have been made at Coleman NFH during the nearly 40-year history of operation. These improvements were designed to increase fish production by improving and expanding the water supply and drainage system, providing better water quality for temperature and disease control, and improving fish passage, holding, spawning and rearing facilities. Major improvements through 1962 and the year in which they were implemented included:

1. Construction of a fish diversion dam in Battle Creek, a fishway and adult holding pond (1951).
2. Installation of a 6-inch well and 450 gallons per minute (gal/min) pump to supplement hatchery water supply (1959).
3. Construction of a spawning building (1960).
4. Construction of thirty 8- by 80-foot rearing ponds and a 40- by 240-foot adult holding pond (1962).

By 1963, annual production capacity of the Coleman NFH was reassessed at 40 million chinook salmon, steelhead trout and Kamloops trout eggs, fingerlings, and yearling fish weighing 250,000 pounds (U.S. Fish and Wildlife Service, 1963). As rearing capability was considered maximum for the existing water supply and rearing facilities, FWS increased available water supplies from Battle Creek and ground-water sources. Improvements, which increased production capability to approximately 350,000 pounds, included:

1. Construction of a new 48-inch water supply line (1964).
2. Installation of two additional 300-foot wells and ponds (1964).
3. Construction of a new 37- by 221-foot holding pond (1965).

4. Construction of a water reuse system (1968).

5. Total water rights for 122 ft^3/s from Battle Creek (1961, 65).

During the 1970's, improvements at Coleman NFH consisted primarily of providing pollution abatement facilities and improving the water reuse system and water temperature control capability. These measures were designed to improve the quality and survival of fall-run chinook salmon smolts produced by the facility and to provide for a limited production of winter- and spring-run chinook salmon.

Most of the original redwood fish troughs in the hatchery building have been replaced with modern vertical flow incubators and rectangular fiberglass rearing tanks. The water reuse system has been remodeled to provide improved temperature control and recirculation for 15 of the 30 (8 x 80) raceways. Two large chillers (1,500 gal/min combined capacity) were recently installed. These will be used to cool Battle Creek water in the late spring and summer for spawning and rearing winter- and spring-run chinook salmon trapped at Keswick Dam or volunteering into the hatchery from Battle Creek. Unfortunately, high energy costs and budget limitations have precluded operation of the chillers.

CVP project use power is not available to Coleman NFH; electrical power needs must be purchased through Pacific Gas and Electric Company (PG&E). Present power costs at Coleman NFH are approximately $32,000 or about 5.0 percent of the annual operations and maintenance budget.

The Coleman NFH has a current capacity to incubate approximately 30 million eggs and produce approximately 20 million salmon and steelhead trout weighing approximately 350,000 pounds annually. The fall-run chinook salmon is the primary species propagated, followed by late fall-run chinook and steelhead trout. Coleman NFH produces approximately 10 percent of the fall-run chinook salmon run and 70 percent of the steelhead trout run to the Upper Sacramento River (U.S. Fish and Wildlife Service, 1979b; Hallock, California Department of Fish and Game, (retired), pers. comm.). Coleman NFH also has a limited capacity for spring and winter chinook salmon production. Eggs are collected from salmon returning to Battle Creek and from fall- and late fall-run chinooks which are collected at the Keswick Fish Trap. Since the winter-run chinook salmon population has declined dramatically during recent years, rearing smolts at Coleman and releasing them to Battle Creek is one way of augmenting the natural population.

The 5-year mean annual production for Coleman NFH from 1975 through 1979 was 8,700,000 salmon and steelhead trout combined weighing 365,000 pounds. From 1980 through 1984, the 5-year mean annual production was over 15 million salmon and steelhead trout. The increased production reflects recent hatchery improvements.

CHINOOK SALMON PRODUCTION

The Coleman NFH was originally designed to incubate 58 million salmon eggs, requiring approximately 12,000 female fish. Although over 50 million chinook eggs were collected in 1959 and 1962, the average number of salmon eggs taken at the facility during its 40-year history has been less than 20 million (table 2). Original rearing facilities limited production to a maximum annual output of about 40 million 1-1/2 to 2-inch-long fingerlings and 2 million 5- to 7-inch-long fingerlings (Cope and Slater; 1957, U.S. Fish and Wildlife Service, 1963). Annual chinook salmon release data are summarized in table 2.

During the 1940's, both spring- and fall-run chinook salmon were propagated at Coleman NFH. Juvenile salmon production ranged from 3.5-23.4 million fall-run chinook annually but usually less than 3 million spring-run chinook salmon. Juvenile salmon were released directly into Battle Creek in the spring as fry and fingerlings. Some were held through the summer and released in the fall when irrigation demand ceased or at least diminished, in order to prevent losses to irrigation diversions.

The number of spring-run chinook salmon propagated at the facility had declined significantly by 1947 primarily because of poor returns to the Keswick Fish Trap and the Battle Creek racks. Adult spring-run chinook ascend the Sacramento River in the spring, remain in deep pools during the summer where cool water temperatures occur, and spawn in the autumn (September and early October). The Coleman NFH often experienced high mortalities of adult spring-run chinook salmon held for ripening due to high water temperatures (U.S. Fish and Wildlife Service, Coleman annual reports, 1943-51). Consequently, spring-run chinook salmon were not propagated after 1952 (1951 brood year; brood year is the year the eggs were taken).

During the 1950's, the annual collection of fall-run chinook salmon eggs at Coleman NFH increased considerably, ranging from 10 million (1950) to 52 million eggs (1959). These eggs were obtained from both fall and late fall-run chinook stocks, the latter primarily coming from

Table 2. Annual chinook salmon production at Coleman National Fish Hatchery, 1943-1984. Referenced from Annual Report, Coleman National Fish Hatchery, 1943-1985.

Brood year	Source of spawners and date collected	Race	Female	Male	Jacks	Adults released and/or mortality	Total handled	Egg take	Fry produced	Juveniles released: Fingerlings before Apr. 15	Juveniles released: Fingerlings after Oct. 1
43	Battle Ck (9/12-10/20)	Spring	227	417		927	944	935,000	838,000	714,000	47,00
	Balls Ferry & Kes (9/12-10/20)	Spring	27				654	119,000			
	Balls Ferry (10/20-11/29)	Fall	1,541	3,215		4,892	9,648	8,320,853	7,775,000	7,533,000	130,00
44	Battle Creek (9/18-10/25)	Spring	116	2,177		2,201	1,181	476,000	—	409,000	
	Balls Ferry & Kes (9/18-10/25)	Spring	732				4,045	3,564,000	3,052,000	2,586,000	170,00
	Balls Ferry(10/18-11/20)	Fall	2,006	4,535		3,475	10,016	11,299,000	—	10,019,000	257,00
45	Battle Ck(9/16-10/22)	Spring	31	359		1,631	468	128,000	120,000	88,000	25,00
	Balls Ferry & Kes (9/16-10/22)	Spring	224				1,777	1,154,000	1,039,000	683,000	202,00
	Balls Ferry (10/13-11/29)	Fall	2,966	3,204		5,104	11,274	20,579,000	18,061,000	16,916,000	691,00
46	Battle Ck (9/24-10/15)	Spring	328	991		1,131	2,450	1,476,000	1,371,603	986,000	297,00
	Battle Ck (10/8-11/20)	Fall	1,801	4,817		3,579	10,197	11,131,000	10,775,000	9,625,000	301,00
	Keswick (9/4-10/15)	Spring	237	880		1,001	2,118	1,287,000	1,190,000	823,000	277,00
	Keswick (11/4-12/5)	Fall	2,379	4,361		796	7,536	14,403,000	13,807,000	13,185,000	290,00
47	Battle Creek (9/16-10/6)	Spring	38	16		134	188	165,000	134,000	75,000	43,00
	Battle Creek (10/1-12/5)	Fall	1,947	5,852		8,155	15,954	10,875,000	10,339,000	8,537,000	1,547,00
48	Battle Creek (10/1-11/30)	Fall	614	419	1,059	282	2,374	3,620,000	3,662,000	1,608,000	1,915,00
	Keswick (10/16-10/30)	Fall	27	75	—	—	102				
49	Battle Ck (9/1-10/17)	Spring	40	38	21	13	112	207,000	199,000	32,000	151,00
	Battle Creek (10/22-12/8)	Fall	2,221	1,201	1,835	271	5,528	13,221,000	12,890,000	10,887,000	1,807,00
50	Battle Creek (9/20-10/22)	Spring	153	105	314	258	830	870,000	799,000	631,000	128,00
	Battle Creek (10/22-12/18)	Fall	1,384	695	1,669	357	4,105	7,438,000	10,156,000	8,107,000	1,566,00
	Keswick (11/2-12/22)	Fall	508	324	233	84	1,149	3,152,000			

Brood year	Source of spawners and date collected	Race	Female	Male	Jacks	Adults released and/or mortality	Total handled	Egg take	Juveniles released: fry & fingerlings (spring)	Juveniles released: sub-yearlings (fall)
51	Battle Creek (9/18-10/19)	Spring	158	205	1,464	5	1,832	987,000	19,924,000	1,483,764
	Battle Creek (10/23-11/21)	Fall	2,855	1,013	5,190	450	9,508	17,208,000		
	Keswick (11/13-12/3)	Fall	925	723	1,127	223	2,998	5,806,000		
52	Battle Creek (10/22-12/10)	Fall	3,607	3,574	3,880	398	11,459	20,074,000	28,220,000	1,483,764
	Keswick (11/19-12/19)	Fall	2,097	1,488	653	423	4,661	14,248,000		
53	Battle Creek (9/30-12/8)	Fall	4,335	2,787	4,641	735	12,498	26,553,000	33,900,000	3,157,000
	Keswick (11/18-12/17)	Fall	2,750	1,730	1,276	1,037	6,793	18,232,000		
54	Battle Creek (9/30-12/22)	Fall	2,091	2,215	3,151	355	7,812	11,191,000	17,307,000	2,713,000
	Keswick (11/18-12/23)	Fall	2,160	1,981	1,480	376	5,997	12,308,482		
55	Battle Creek (9/30-12/31)	Fall	2,796	3,348	4,243	189	10,576	15,907,000	22,907,000	3,781,000
	Keswick (11/17-1/9)	Fall	2,202	1,401	1,016	326	4,945	13,606,000		
56	Battle Creek (10/1-1/21)	Fall	2,725	2,246	1,770	617	7,358	15,043,000	14,689,000	3,808,000
	Keswick (11/19-12/31)	Fall	1,066	811	327	457	2,661	6,551,000		
57	Battle Creek (10/4-2/10)	Fall	826	425	1,546	248	3,045	4,106,000	11,167,000	3,225,000
	Keswick (11/15-1/27)	Fall & late fall	2,626	2,225	1,388	2,990	9,229	15,154,000		
58	Battle Creek (9/16-2/13)	Fall	4,054	4,629	6,344	570	15,597	19,681,000	5,220,000	2,267,050
	Keswick (11/17-2/13)	Fall & late fall	2,916	2,422	1,388	6,821	13,517	17,268,000		
	Keswick	Winter	136	—	—	—	420	381,000		3,000
59	Battle Creek (9/28-1/20)	Fall	5,632	3,934	824	473	10,863	33,474,000	30,517,000	4,506,000
	Keswick (11/16-1/29)	Fall & late fall	3,047	3,021	605	893	7,566	19,189,000		
60	Battle Creek (10/5-1/16)	Fall	2,923	2,652	3,866	164	9,605	18,612,000	29,126,000	4,089,140
	Keswick 11/16-1/23)	Fall & late fall	3,429	2,554	2,320	1,556	9,859	21,900,000		
61	Battle Creek (10/6-1/24)	Fall	3,577	3,069	1,645	212	8,503	22,221,000	17,080,000	3,988,000
	Keswick (11/13-3/5)	Fall & late fall	2,263	2,396	427	561	5,647	13,315,000		
62	Battle Creek (10/1-1/15)	Fall	3,396	2,926	1,424	327	8,573	21,192,000	34,192,000	5,449,000
	Keswick (11/17-3/24)	Fall & late fall	4,420	4,070	1,511	5,661	15,662	32,079,000		
		Winter					214	60,000		35,000
63	Battle Creek (10/7-2/18)	Fall	2,356	2,048	618	92	5,114	14,500,000	1,428,000	5,889,000
	Keswick (11/17-3/24)	Fall & late fall	2,105	1,686	284	196	5,125	13,500,000		
	Keswick (5/23-7/12)	Winter	53	—	—	—	754	236,000	(50,000 sent to Australia)	73,000
64	Battle Creek (10/8-?)	Fall	1,585	1,153	1,109	26	3,873	10,103,500	13,239,000	5,375,000
	Keswick (11/27-3/16)	Fall & late fall	1,239	423	119	2,035	3,816	8,053,500		

Table 2 (continued)

Brood Year	Source of spawners and date collected	Race	Female	Male	Jacks	Adults released and/or mortality	Total handled	Egg Take	Eyed Eggs	Juveniles released: Fingerlings (spring)	Juveniles released: Sub-yearlings (fall)
65	Battle Ck (10/5-3/7) and	Fall	2,893	2,578	471	285	3,256	19,291,000	17,701,000	2,597,000	7,483,000
	Kes (11/15-2/23) combined	Late Fall					2,976				
	Keswick (6/14-6/30)	Winter	16	6	-	-	22	80,000	?	53,000	(5/65)
66	Battle Creek (10/3-3/25)	Fall &									
	& Keswick (11/1-3/25)	Late Fall									
	combined		1,907	1,270	584	234	3,995	12,714,000	11,732,000	125,000	6,157,000
	Keswick (6/3-6/30)	Winter	2				7	6,000	-	4,300	
67	Battle Creek (10/13-3/25)	Fall &									
	and Keswick (11/6-3/25)	Late Fall					7,440	18,200,000			
	combined		3,094	2,151	1,402	458	(4,400 from Keswick)		17,450,000	2,394,000	7,363,000
	Keswick	Winter	7				215	17,500	?	16,000	
68	Battle Creek (10/1-3/21)	Fall &									
	and Keswick (11/15-3/21)	Late Fall	2,077	1,465	2,111	1,514	7,167	11,479,000	10,658,000	1,278,000	2,281,000
	combined						(1,240 from Keswick)				
							(2,376 from ACID trap)				
69	Battle Creek (10/10-1/10)	Fall &									
	and Keswick (11/19-3/20)	Late Fall	2,951	1,831	827	827	6,436	16,716,000	15,412,000	2,947,000	3,057,000
	combined						(4,112 from Keswick)				
70	Battle Creek (10/16-3/22)	Fall &									
	and Keswick (10/29-3/22)	Late Fall	3,335	1,881	1,321	982	7,519	20,315,000	19,396,000	5,129,000	2,619,000
	combined						(4,053 from Keswick)				
71	Battle Creek and Keswick	Fall &									
	combined (10/22-3/8)	Late Fall	1,811	918	1,127	442	4,298	11,859,000	11,151,000	7,203,000	-
							(2,190 from Keswick)				
72	Battle Creek (10/6-1/5)	Fall &	913	721	1,449	142	3,225	5,729,000	5,425,000	4,697,000	-
	and Keswick (11/9-1/10)	Late Fall					(403 from Keswick)				
	combined										
73	Battle Creek (10/12-12/12)	Fall	1,547	1,139	816	333	3,835	8,690,000	8,458,000	4,927,000	-
	Keswick (1/24-3/15)	Late Fall	310	248	126	19	705	2,149,000	1,966,000	1,687,000	-
74	Battle Creek (10/18-12/6)	Fall	1,096	565	348	206	2,175	6,390,000	6,062,000	1,910,212	-
	Keswick (12/10-3/7)	Late Fall	638	346	77	487	1,498	4,113,000	3,760,000	33,000	1,896,000
75	Battle Creek (10/10-12/5)	Fall	1,125	652	690	228	2,695	7,037,000	6,717,000	2,801,000	1,112,000
	Keswick (12/2-1/16)	Late Fall	200	195	29	185	609	1,277,000	1,168,000	-	602,000
76	Battle Creek (9/2-12/3)	Fall	1,552	688	839	675	3,971	9,608,000	9,105,000	6,519,000	593,000
	Keswick (12/10-2/11)	Late Fall	273	176	20	287	756	1,610,000	1,483,000	-	628,000
77	Battle Creek (9/27-12/2)	Fall	1,973	608	492	1,491	4,852	12,670,000	11,746,000	3,278,000	-
	Keswick (12/6-1/7)	Late Fall	470	536	110	737	1,853.	3,178,000	3,004,000	-	1,971,000
78	Keswick (5/2-6/23)	Winter	29	34	-	-	63	121,000	102,000	-	10,250
	Battle Creek (10/12-12/1)	Fall	452	374	830	215	1,872	2,122,000	2,021,000	427,000	1,213,000
	Keswick (12/8-2/9)	Late Fall	325	335	21	148	829	1,738,000	1,617,000	-	982,000
79	Battle Creek (10/2-11/30)	Fall	2,669	1,742	3,894	419	8,729	15,639,000	14,809,000	11,072,000	615,000
	Keswick (12/10-2/29)	Late Fall	373	276	38	180	867	2,123,000	2,013,000	490,000	928,000
80	Battle Creek (10/10-11/28)	Fall	3,580	3,023	572	558	7,733	17,804,000	16,502,000	14,495,000	-
	Keswick (12/1-2/11)	Late Fall	814	684	190	377	2,065	3,614,000	3,198,000	-	2,575,522
81	Battle Creek (10/2-11/30)	Fall	2,233	1,035	7,323	882	11,473	11,496,771	10,046,522	403,169	8,589,294
	Keswick (10/16-11/30)	Fall	-	-	-	-	1,867				
	Battle Creek (12/3-2/18)	Late Fall	43	97	7	5	152	2,787,925	2,597,300	714,820	1,686,824
	Keswick (12/3-2/18)	Late Fall	510	470	211	543	1,745				
	Keswick (5/11-6/1)	Winter	7	11	0	39	57	30,087	17,421	11,548	-
82	Battle Creek (10/4-11/29)	Fall	5,519	5,264	3,276	5,395	19,361	26,623,713	21,136,970	6,461,860	9,116,218
	Keswick (11/15-11/27)	Fall	-	-	-	-	93				
	Battle Creek (12/2-3/11)	Late Fall	95	63	25	10	183				
	Keswick (12/2-3/11)	Late Fall	271	279	6	219	432	1,887,546	1,628,837	-	1,348,367
	RBDD (11/10-1/21)	Late Fall	-	-	-	-	343				
83	Battle Creek (10/3-12/5)	Fall	2,733	1,295	3,401	1,327	8,756	9,845,886	8,652,885	9,721,000	-
	Keswick (11/9-11/17)	Fall	160	86	16	-	262				
	Battle Creek (1/20-4/5)	Late Fall	51	-	-	-	51				
	Keswick (1/20-4/5)	Late Fall	28	42	286	68	424	669,901	604,846	-	375,000
	RBDD (12/20-2/14)	Late Fall	98	52	3	0	153				
84	Battle Creek (9/24-12/12)	Fall	7,481	8,723	2,916	2,063	21,543	27,815,000	25,431,000	24,109,732	-
	Battle Creek (12/19-1/17)	Late Fall	23	36	12	19	90	96,600	79,200	data unavailable	-
	Keswick (12/17-4/2)	Late Fall	118	106	30	44	298	500,800	413,000	data unavailable	-

the Keswick Fish Trap. No breakdown in the propagation of the two races is provided in early hatchery records and they were generally lumped together as "fall-run" chinook salmon production. Juvenile fall-run chinook salmon were released in parent waters (Battle Creek or the Sacramento River) as 1-1/2 to 2-inch fingerlings in the spring. Approximately 3 million were released in the fall as 4- to 5-inch yearlings. Some fish were supplied to the DFG for supplementing depleted runs of salmon in Clear Creek, Mill Creek, Deer Creek (a small tributary streams to the Sacramento River), Mokelumne River (a tributary to the San Joaquin River), and Russian River (a stream in Northern California which flows into the Pacific Ocean). As the production of fall-run chinook salmon increased, available rearing facilities and water supplies were maximized in order to increase the average juvenile release size and thereby improve survival to returning adult. However, disease problems were encountered and a steadily increasing loss was suffered. In 1957, the loss was attributed to a filterable virus and studies were initiated to identify its source and mode of transmission and to develop control measures (Ross, Pelnar, and Rucker, 1960).

Between 1958 and 1963, the annual number of fall-run chinook salmon eggs collected at Coleman NFH varied from 28 to 53 million with a mean of 41 million. This was the highest egg take period in the facility's 40-year history. However, survival rates from egg to fingerling release size declined due to juvenile disease losses. Mean survival, usually 80 percent or higher, dropped to about 50 percent. The cause of this loss was identified as a coldwater virus, referred to at that time as

Sacramento River Virus Disease (Parisot and Pelnar, 1962). It has since been identified as IHN. This disease usually affects small salmon fingerlings that have been feeding for about one month and results in high mortalities. The most effective measure in controlling outbreaks of IHN is to increase water rearing temperature to 55 °F. This often proved difficult because of coldwater temperatures in Battle Creek. Consequently, measures were taken to improve water temperature control and expand rearing area.

From 1963 through 1978, the annual number of fall- and late fall-run chinook salmon eggs collected for the Coleman NFH at Battle Creek and Keswick Dam decreased gradually from a high of 28.0 million (1963) to only 3.8 million (1978). The average annual number of eggs collected from 1964 through 1970 was 15.25 million. The mean annual egg take from 1970 through 1978 declined to less than 9.5 million. In the past several years, however, the number of eggs collected at Coleman NFH and the percent survival of juvenile release size have increased substantially, hopefully reflecting improved propagation and disease control techniques developed at the facility. The run sizes of fall-run chinook returning to the hatchery in 1984 (21,543 spawners) and 1985 (27,016 spawners) were the largest in Coleman's history.

Cooperative programs with the DFG were undertaken whereby excess State hatchery eggs were shipped to Coleman NFH for hatching and rearing. Most of these excess eggs came from the Nimbus Fish Hatchery on the American River. The Coleman NFH, in return, entered into a program of trucking and releasing a portion of its juvenile salmon production into the lower Sacramento River (Rio Vista and Princeton) in 1969. The objective of releasing fish at downstream sites was to improve smolt survival and adult returns to the fishery. Although survival appeared to be improved by this measure (based on tagging studies), the number of adult salmon spawners returning to Coleman NFH from these releases were significantly reduced, thus compounding egg supply problems. Transporting juvenile salmon to release sites in the lower Sacramento River was discontinued after 1976. At the present time, about half of the production is released just below RBDD and half is released into Battle Creek from the hatchery raceways.

Late fall-run chinook salmon production has generally been included in fall-run chinook hatchery production records. The late fall run, sometimes referred to in the literature as the early winter run, is a distinct race of chinook salmon which enter the upper Sacramento River from December through February and spawn from January through mid-March. The mean annual run count for adult late fall-run salmon migrating upstream past RBDD since 1967 is 15,236. In recent years, there has been a downward trend in the annual counts. Peak counts exceeding 32,000 occurred in 1967 and 1972 while the minimum count of 4,913 occurred in 1982 (table 3).

Late fall-run chinook salmon are collected at the Keswick Fish Trap late in the season and are artificially propagated at the Coleman NFH. Juveniles were released in the late spring and fall. In recent years, however, these fish have been reared through the summer and fall and released in the winter as yearling smolts. Since 1973, an average of

Table 3. Salmon and steelhead counts, Red Bluff Diversion Dam, Sacramento River. Data taken from Red Bluff Diversion Dam Annual Fish Count Report, 1967-1985.

Year	Late fall	Winter	Spring	Fall	Total salmon	Steelhead trout
1967[a,b]	32,891	49,533	23,441	89,220	195,085	15,375
1968[b,c]	30,996	84,414	14,446	122,095	251,951	13,776
1969[b,d]	8,899	117,808	26,471	133,815	286,993	10,995
1970[b,e]	16,567	81,189	3,652	80,935	182,343	10,574
1971	16,741	53,089	5,830	63,918	139,578	5,206
1972	32,651	37,133	7,346	42,503	119,633	7,678
1973	23,010	24,079	7,762	53,891	108,742	6,002
1974[f]	6,300	19,116	3,932	54,958	84,306	5,084
1975	19,659	23,430	10,703	63,091	116,883	8,196
1976	16,198	35,096	25,983	60,719	137,996	5,928
1977[g]	10,602	17,214	13,730	40,444	81,990	2,467
1978	12,586	24,862	5,903	39,826	83,177	3,487
1979	10,398	2,364	2,900	62,108	77,770	10,994
1980	9,481	1,156	9,696	37,610	57,943	2,898
1981	6,807	20,041	21,025	53,744	101,617	2,394
1982	4,913	1,242	23,438	48,431	78,024	3,294
1983	15,190	1,381	3,491	42,961	63,023	1,968
1984	7,163	2,663	8,147	73,254	91,227	4,404
1985	8,436	3,962	10,747	97,707	120,852	3,447[h]
1986	6,988[h]					
Average (1967-85)	15,236	31,567	12,034	66,380	125,217	6,535

[a] 8-hour counts, adjusted for 14-hour counting period (x 1.75).

[b] Counts reconstructed for late fall, winter and spring runs by adjusting actual fish counts to respective run components each week using 1971-82 averages. Fall chinook counts are spawning stock estimates above RBDD.

[c] Winter chinook adjusted for missing counts (actual count 61,369). Steelhead adjusted for missing counts (actual count 6,389).

[d] Fall chinook count unadjusted (21 weeks of missing counts due to high flows). Winter chinook adjusted for missing counts (actual count 80,934).

[e] Winter chinook adjusted for missing counts (actual count 52,185).

[f] Fall chinook count unadjusted (6 weeks of counts missing).

[g] Less 1,625 spring and 20,539 fall chinook trapped and transported to tributaries and hatcheries because of the drought.

[h] Incomplete count.

1,467,000 late fall-run chinook subyearlings have been produced annually at the hatchery (range: 597,000 to 2,575,000).

Winter-run chinook salmon appear below Keswick Dam and in Battle Creek from April through June. This run usually spawns in the upper Sacramento River from May through mid-July. The average annual count of adults migrating past RBDD since 1967 has been 31,567 fish, ranging from 117,808 in 1969 to only 1,156 in 1980 (table 3). These fish provide an excellent sport fishery in the Sacramento River, but their natural production is limited because of decreasing availability of cool water and suitable spawning gravel in the upper Sacramento River.

At one time, eggs were taken from winter-run chinook adults collected at Keswick Fish Trap and incubated in Sacramento River water at Keswick Dam (Fish and Wildlife Service unpublished data). The Coleman NFH has handled only small numbers of this race because of the lack of facilities to retain adults until maturation in June.

In order to raise winter-run chinook salmon, an adult holding pond, deep enough to maintain cool water temperature is needed. Properly designed facilities will have a direct, positive effect on adult survival.

STEELHEAD TROUT PRODUCTION

Steelhead trout eggs were first collected from Battle Creek in 1947 (brood year 1946). Propagation of these fish through the 1950's was relatively minor. The annual egg take, however, increased steadily from only a few hundred thousand to 827,000 by 1958 (table 4). In 1958, a cooperative program to increase trout production at the Coleman NFH was

Ta[redacted]le 4. Steelhead trout production, Coleman National Fish Hatchery, 1946-1985.
R[redacted]erenced from Annual Report, Coleman National Fish Hatchery, 1946-1985.

Br[redacted]od Ye[redacted]r		Total No. Trapped	Origin	No. Females Spawned	No. Males Spawned	No. Eggs Collected	No. Juveniles Released
19[redacted]6		--	Keswick & Battle Ck.	19	--	31,000	--
[redacted]7		--	Battle Creek	9	--	18,000	--
948		--	Battle Creek	70	--	178,000	--
9[redacted]9		--	Battle Creek	205	--	326,000	--
[redacted]0	50	--	Battle Creek	79	--	160,000	--
9[redacted]1		--	Battle Creek	78	64	168,000	64,000
952		--	Battle Creek	129	--	272,000	152,000
9[redacted]3		424	Battle Creek	158	106	380,000	177,000
9[redacted]4		960	Battle Creek	156	88	466,000	286,000
955		920	Battle Creek	169	69	501,000	237,000
[redacted]		143	Keswick				
9[redacted]6		779	Battle Creek	286	89	600,000	159,000
		110	Keswick				
957		882	Battle Creek	279	82	706,000	289,000
[redacted]		80	Keswick				
9[redacted]8		681	Battle Creek	287	137	827,000	372,000
		135	Keswick				
9[redacted]9		696	Battle Creek	357	207	791,000	112,000
[redacted]		296	Keswick				
960	60	1,256	Battle Creek	545	195	1,583,000	553,000
[redacted]		397	Keswick				
9[redacted]		1,639	Battle Creek	699	256	1,810,000	1,214,000
		100	Keswick				
962		1,347	Battle Creek	724	275	2,000,000	467,000
[redacted]		139	Keswick				
9[redacted]		1,594	Battle Creek	732	303	2,250,000	1,532,000
		143	Keswick				
9[redacted]		2,920	Keswick & Battle Ck.	1,238	313	3,713,000	1,395,000
[redacted]		45	Keswick				
965	65	1,643	Keswick & Battle Ck.	737	368	2,561,000	1,182,000
9[redacted]		1,532	Keswick & Battle Ck.	854	483	2,706,000	1,443,000
9[redacted]		3,229	Keswick & Battle Ck.	1,213	216	3,000,000	1,423,000
968		4,939	Keswick & Battle Ck.	647	335	2,596,000	656,000
969		3,967	Battle Creek	758	204	2,811,000	1,606,000
[redacted]		79	Keswick				
9[redacted]0	70	3,592	Battle Creek	900	888	3,391,000	2,247,000
		150	Keswick				
9[redacted]		1,377	Battle Creek	393	350	1,282,000	934,000
[redacted]		109	Keswick				
972		2,645	Keswick & Battle Ck.	1,007	900	3,131,000	2,109,000
9[redacted]		1,834	Keswick & Battle Ck.	655	218	2,129,000	1,409,000
9[redacted]		1,099	Keswick & Battle Ck.	431	301	1,840,000	1,078,000
975		2,162	Keswick & Battle Ck.	588	636	2,357,000	1,228,000
976	77	2,069	Keswick & Battle Ck.	630	--	2,188,000	1,100,000
9[redacted]	78	697	Keswick & Battle Ck.	201	--	804,000	271,000
9[redacted]	79	865	Keswick & Battle Ck.	257	--	955,500	553,000
979	80	4,264	Keswick & Battle Ck.	751	--	3,229,000	1,972,000
9[redacted]	81	1,118	Keswick & Battle Ck.	324	--	1,173,000	402,000
9[redacted]	82	1,250	Keswick & Battle Ck.	525	--	1,575,000	1,270,000
982	83	938	Keswick & Battle Ck.	380	183	1,398,000	833,000
98[redacted]	84	650	Keswick & Battle Ck.	122	108	459,600	289,000
9[redacted]*	85	2,565	Keswick & Battle Ck.	715	363	2,723,800	data unavailable

*Changed brood year designation, therefore Brood Year 1984 is designated Brood Year 1985.
[redacted]

initiated between FWS, BOR, DFG, and a sport fishing group, California Kamloops, Inc. This program involved rearing and planting Kamloops trout in Shasta Lake and steelhead trout in the Sacramento River. Steelhead trout were reared to yearling size (5-7 inches) and released directly into Battle Creek. Some were made available to the DFG for studies to evaluate the stocking of hatchery-reared fish (Hallock, 1961). As a result of these efforts, adult steelhead trout returning to the hatchery increased significantly. The annual egg take from 1960 through 1976 varied from 1.28 to 3.71 million and averaged 2.48 million eggs. Since 1977, however, the numbers of adult steelhead returning to Coleman NFH has decreased substantially, reflecting decreased propagation of these species in order to maximize salmon production. With the exception of brood year 1979 when the steelhead egg take exceeded 3 million, egg collections from 1977 to 1985 have averaged 1.3 million.

Another situation which has had a severe impact on the steelhead production at Coleman NFH is the recent discovery of whirling disease infecting hatchery juvenile stock. A discussion of whirling disease is presented later in this chapter.

CURRENT STATUS

Current annual production goals at Coleman NFH are:

Species	Size	Weight	Number	Distribution area
Fall chinook	90/lb	12,000,000	133,000	Sacramento River
Late fall chinook	40/lb	2,000,000	50,000	Sacramento River
Steelhead trout	7/lb	1,000,000	143,000	Sacramento River
		15,000,000	326,000	

The annual operating budget for Coleman NFH in FY 1985 was $661,690. Approximately 64 percent of the budget was expended on labor, 23 percent on fish food, 5 percent on electrical energy and 7 percent on supplies and materials. The station operates with a permanent staff of 14 employees. Temporary labor is used to supplement the permanent staff.

Hatchery Staffing

Hatchery Manager	GS-12
Assistant Hatchery Manager	GS-11
Fishery Biologist	GS-7/9
2 - Animal Caretaker - Lead	WL-5
4 - Animal Caretaker	WG-7
2 - Animal Caretaker	WG-3
2 - Maintenance Mechanic	WG-10
Hatchery Assistant - Typing	GS-5
Permanent Staff Years of Labor	14.0
Temporary Staff Years of Labor	1.0
Total Staff Years of Labor	15.0
Fish Production per Staff Year of Labor	22,300 lbs.

Visitor use at Coleman is estimated to be 80-100,000 visitor days annually. Interpretation, environmental education, and steelhead fishing are the major public uses of the station.

HATCHERY OBJECTIVES

The original objective of the Coleman NFH and the Keswick Fish Trap was to help perpetuate the displaced chinook salmon runs of the upper Sacramento River by supplying additional spawning facilities. The objective at Coleman NFH was later broadened to include production of steelhead and Kamloops rainbow trout. Kamloops trout fingerlings were reared to stock Shasta Lake and Whiskeytown Lake since these reservoirs were created by Federal projects. Limited numbers of rainbow trout were also reared and stocked in military and Indian reservations to meet the FWS's responsibility to provide fish and wildlife assistance to Cooperative Federal Areas. Through a fish exchange program between State and Federal Governments, DFG stocked Federal management areas in the southern portion of California in exchange for Coleman NFH's participation in rearing and stocking more trout in Whiskeytown and Shasta Lakes.

Recently, in association with the FWS Regional Resource Planning process, production objectives for Coleman NFH were modified to increase the chinook salmon contribution to commercial and sport fisheries and steelhead trout contribution to sport fisheries. These objectives have influenced development proposals contained in the present station development plan and also necessitated elimination of the resident trout program.

The specific population objective contained in the FWS's Regional Resource Plan (RRP) (U.S. Fish and Wildlife Service, Regional Resource Plan, 1982), to which the Coleman's production is a primary contribution is as follows:

> "To restore chinook salmon stocks of the upper Sacramento drainage to levels of the 1950's (adult contribution of 673,000[1] fall chinook, 50,000 late fall chinook, 80,000 winter chinook and 130,000 spring chinook)."

Implementation strategies that relate specifically to Coleman NFH are listed within the RRP to achieve this objective. Proposed development projects included in the station development plan will consider each of the strategies to the greatest extent possible. Strategies are:

---

[1] Figures include sport and commercial fisheries catch plus returning adults.

1. Control disease.
2. Control water temperature in an energy-efficient manner.
3. Increase Coleman hatchery capacity to accommodate winter-run chinook.
4. Optimize production pond loading and smolt release at hatcheries.
5. Increase egg to smolt survival through improved health and physiological fitness.
6. Plan, design, and construct new propagation capacity as needed.
7. Provide water temperatures that do not exceed 50 °F for holding winter- and spring-run adult salmon.
8. Maintain capability to distribute fish so as to maximize adult contribution while insuring sufficient brood stock returns to the hatchery (present evidence suggests this will require a distribution of a substantial share of production below RBDD).
9. Provide facilities and systems that will reduce the probability of catastrophic fish losses to acceptable lower levels.

Finally, to further step down these broad RRP goals and strategies into meaningful operational statements, FWS regional office supervisors and field managers have proposed numerical objectives for various phases of production at Coleman NFH (table 5). These objectives are based on best professional judgment and program guidance available at this time.

The achievement of hatchery objectives at Coleman NFH will depend greatly upon improvement of water supplies. Some important planning assumptions in improving water supplies and meeting objectives are:

1. Coleman NFH has a history of significant disease and parasite problems.

Table 5. Coleman National Fish Hatchery production objectives.
(Taken from Coleman Hatchery Station Development Plan, March 1984, p. 10.)

Stock	Adult brood stock required		Eggs required		Juveniles requiring temperature-controlled environment		Smolts released		Regional Resource Plan[a] "Adult Contribution" objectives	
	5 Yr Mean	Future	5 Yr Mean[b]	Future[c]	5 Yr Mean	Future	5 Yr Mean	Future	Current	Future
Fall chinook	4,310	7,000	11,946,000	13,000,000	10,785,000	12,500,000	8,018,000	11,000,000	40,000	55,000
Late fall chinook	1,385	800	2,688,000	1,400,000	2,352,000	1,300,000	1,727,000	1,000,000	17,300	10,000
Winter chinook		1,000		2,000,000				1,500,000		15,000
Spring chinook		1,000		2,500,000				2,000,000		20,000
Steelhead trout	1,578	1,300	1,591,000	1,300,000			855,000	1,000,000	4,300	5,000

Notes:

a RRP objectives are catch plus escapement.
b Coleman production only; eggs and fry received from State of California not included.
c Future goals reflect anticipated reduction in mortality due to development.

2. Water for use in the hatchery building and 8- by 80-foot raceways must be treated (sand removal and/or ozone).
3. Reuse system and water chilling energy requirements should be managed (along with other hatchery systems) below a 500-kW ceiling due to economic factors.
4. Current annual operation and maintenance costs associated with the six existing filter beds are ± $30,000.
5. Water must be maintained at 57 °F during certain periods of the young salmon life cycle in order to minimize IHN disease.
6. It is more cost effective to pump warm well water than to heat Battle Creek water.

PAST EVALUATION OF FACILITIES

Numerous studies have been conducted at Coleman NFH to evaluate hatchery propagation measures and improve salmon and steelhead production.

Early evaluations confirmed that the facility played an important role in maintaining runs of fall-run chinook salmon and steelhead trout in the upper Sacramento River (Azevedo and Parkhurst, 1957; Cope and Slater, 1957; and Hallock, et al., 1961). These studies were designed to identify the overall success of the facility in contributions to the commercial and sport fishery and to determine the proper time, size, and site for release of hatchery fish. Analysis of marked fish returns indicated that juveniles reared to fingerling and yearling release sizes contributed substantially more than juveniles released as fry.

Salmon marking experiments were first undertaken at Coleman NFH shortly after the facility went into production. The objectives were: (1) To identify contributions made by the hatchery to commercial and sport fisheries, and (2) to compare the difference between results of spring and fall releases. Paired groups of juvenile salmon were fin clipped and released from brood years 1944, 1945, 1947, and 1948. From 1946 to 1952, recovery data were recorded from commercial landings, sport fish harvest, and hatchery returns. The study indicated that Coleman NFH releases accounted for approximately 19 percent of the commercial gill net catch (Cope and Slater, 1957). The gill net fishery harvested from 33,000 to 291,000 salmon annually between 1946 and 1952. Assessment of the hatchery's contribution to the ocean troll fishery (commercial and sport) and to the inland sport fishery was incomplete because of the paucity of sampling data. Rate of return of adult spring- and fall-run chinook to the hatchery was 0.207 percent and 0.244 percent, respectively. These return data indicated that chinook salmon released in the fall (13.5 to 19.1 per pound) had a higher survival rate, entering the commercial fishery and returning as adults in greater numbers than spring-released fish (181 to 304 per pound). However, the fall-released fish were much smaller in size at maturity.

Later studies conducted by the DFG and FWS with assistance from California sport fish organizations were undertaken to determine whether survival and contribution of hatchery produced salmon could be improved by releasing juveniles in the lower Sacramento River. In 1959 (brood year 1958), marked Coleman NFH fish were released at several downstream locations including the Sacramento River near Chico, Rio Vista, and in San Francisco Bay (Hallock and Reisenbichler, 1979). The returns to the fisheries and spawning stocks from these releases were considerably greater than from any subsequent brood year. Analysis of returns from six other brood years of Coleman NFH salmon (1959-61 and 1968-70) indicated that those fish released at Rio Vista contributed significantly more to the fisheries (1.5 times more) than those released at the hatchery. However, returns to Coleman NFH from those fish released at Rio Vista represented only 18 percent compared to returns of fish released from Coleman NFH. The low homing tendency for Coleman NFH fish released at Rio Vista was also apparent from the large number of fish which strayed into and were recovered at Nimbus and Feather River Hatcheries. Fingerling mortality rates during the downstream migration from Coleman NFH to Rio Vista were determined by Hallock and Reisenbichler (1979) to be 0.58 for the 1959-61 brood years and 0.29 for the 1968-70 brood years. These studies suggested that hatchery fish released directly into Battle Creek experienced higher mortality rates than fish released in the lower Sacramento River, presumably from increased predation, sport fishing, impacts of the RBDD (after 1966), and increased irrigation diversions. Other investigations tend to support these concerns (Hallock, 1981, 1980c; Menchen, 1980). A mark-recovery program to assess contribution and return rates of juvenile salmon released at three different sites (Coleman NFH, below RBDD and at Knights Landing) was initiated in 1981.

Further analysis of marked releases of Coleman NFH salmon demonstrates the relation between the size of chinook salmon released at the hatchery and their contribution to the fisheries and return spawning run. Marked fingerling salmon were released from Coleman NFH in April-June, 1960, 1961, and 1962 at 1.7 to 2.1 grams (266 to 215 fish per pound) (Hallock, Reisenbichler, and McIntyre, 1980). Subsequent adult recoveries ranged from 0.028 to 0.075 percent in the ocean fisheries and from 0.003 to 0.023 percent returning to the hatchery. In contrast, adult recoveries of larger juvenile salmon (70 to 86 per pound) released at the hatchery during April-June, 1969, 1970, and 1971, produced returns of 0.382 to 0.766 percent in the ocean fisheries and from 0.055 to 0.060 percent returning to Coleman NFH. These studies, all based on fall-run chinook released during the spring, indicate that the larger smolts contribute about 10 times more than the smaller fingerlings.

Studies were conducted by the Fisheries Assistance Office (FAO) of the FWS to determine favorable size and timing criteria for juvenile chinook salmon released at Coleman NFH (U.S. Fish and Wildlife Service, 1979a). Tests were based upon seawater challenges and gill - ATPase (sodium plus potassium ion) enzyme activity analysis and upon recovery of marked juvenile chinook salmon from the Coleman NFH which were released into the dual purpose spawning channel at the Tehama-Colusa Canal Fish Facilities. Preliminary analysis indicated that fall-run chinook greater than 8 cm should be released in May, but, to the greatest extent possible, all remaining fall-run chinook should be reared and released early the following December. Similar tests with winter-run chinook suggest juveniles should be released either during January, or preferably during late April (Hallock, California Department of Fish and Game (retired), pers. comm. 1983).

Many studies have been conducted at Coleman NFH to evaluate methods for the control of fish disease, primarily the coldwater virus IHN (U.S. Fish and Wildlife Service, Coleman NFH annual reports, 1942-80). An experimental program was initiated in 1959 to characterize the virus (Pairsot and Pelnar, 1962). This study indicated a definite relation between water temperature and occurrence of the disease. As water temperature rose to levels greater than 50 °F, the mortality rate diminished; and at a level above 55 °F, the virus appeared to be inhibited. Evaluation of improved temperature control measures, however, showed that heating water to control IHN has several negative results (U.S. Fish and Wildlife Service, 1980), (i.e., elevated water temperature conditions favor other disease and parasite outbreaks, the growth rate of fish is changed from that of natural development, and the water temperature control systems are energy consumptive and expensive to operate, and fish production is subject to interruptions due to mechanical or natural causes.)

Evaluation of steelhead trout production at Coleman NFH indicates that the facility plays an important role in maintaining steelhead runs in the upper Sacramento River (Hallock, Van Woert, and Shapovalov, 1961). Studies indicated that whereas natural reproduction by steelhead was on the order of 1 to 1', artificial propagation produced about 15 fish for each one spawned. The greatest returns were obtained by releasing steelhead trout as yearlings greater than 10 per pound during the normal seaward migration period of wild steelhead in the late winter and early spring. Approximately 2 percent of the average yearlings released returned to the upper Sacramento River as adults.

Yearling steelhead trout released in the lower Sacramento River at Rio Vista failed to return to Coleman NFH in sufficient numbers as adults to justify the releases (Hallock, 1980a). Yearlings from brood years 1969, 1970, and 1971 which were released in Battle Creek returned to Coleman NFH at a magnitude of seven times greater than those released at Rio Vista. These studies also showed that half of the returns from hatchery releases which pass the RBDD reach Coleman NFH. Another study, however, indicated that releasing Coleman NFH yearling steelhead trout in the Sacramento River immediately downstream from the RBDD resulted in increased hatchery returns compared to yearlings released at the hatchery (Hallock, 1980c). Hallock (1980b) also determined that yearling steelhead released from Coleman NFH in February return in much greater numbers than those released in December. Menchen (1980) estimated the sport catch of Coleman NFH yearling steelhead in 1973, based on tagging studies, was 2.7 percent of the combined steelhead released at Balls Ferry and Battle Creek (4.1 percent for Balls Ferry releases and 0.9 percent for the Battle Creek releases). This later study suggests that a significant number of steelhead yearlings released from Coleman NFH are caught before they migrate to the ocean.

Evaluation of stomach samples collected from Coleman NFH yearling steelhead trout released in Battle Creek indicates that these fish prey extensively on wild chinook salmon fry (Frank Hall, 1975, California Department of Fish and Game, pers. comm).

Recent studies conducted by the FAO suggest that the declining run of Coleman steelhead may be a genetic problem (U.S. Fish and Wildlife Service, 1979a). Test groups of marked steelhead trout from Battle Creek and Mad River stocks were placed in the dual-purpose spawning channel at the Tehama-Colusa Fish Facility. Examination of fish emigrating from the facility indicated that only 17 percent of Battle Creek steelhead were recovered and 60 percent of the Mad River steelhead were recovered. This reduced migration tendency may be a result of previous hybridization of Kamloops rainbow with Battle Creek steelhead trout and subsequent selective breeding practices at Coleman NFH (U.S. Fish and Wildlife Service, 1979a).

HYDROLOGY

Water Supply

Battle Creek is the surface water supply source for Coleman NFH. The discharge of Battle Creek is regulated above the hatchery by four small powerplants, several small reservoirs and diversions for irrigation.

A gauging station was operated and maintained continuously by the U.S. Geological Survey less than 1/2 mile upstream from the hatchery from October 1940 to September 1961. The discharge records for that station did not include the water diverted to the hatchery. In October 1961, the gauging station was relocated below the point where water is returned to the stream after passing through the hatchery. The present records of discharge, therefore, include the amount of water used at the hatchery. A summary of mean monthly and yearly discharges of Battle Creek at the gauging station for water years 1961 to 1984 is included in appendix B. That summary indicates a substantial supply of water to be available throughout the year but does not indicate the extremely rapid fluctuation of the stream. It is not unusual for the discharge of Battle Creek to increase over 1,000 ft^3/s within 1 hour. Such an increase occurred on February 7, 1960, when the creek rose 5-1/2 feet in less than 3 hours increasing the discharge from 320 ft^3/s to 5,410 ft^3/s. Appendix B shows the maximum and minimum discharges of record and the dates on which they occurred. The minimum discharges are of very short duration occasioned by powerplant regulation and have, therefore, not interfered with hatchery operation.

High water discharges of over 9,000 ft^3/s have occurred on the average of once every 3 years since 1941. The stage discharge relationship on Battle Creek has changed considerably during that time as a result of the construction of the fish diversion dam and diking which has reduced the cross sectional area of the stream. The lower pond area is within the flood zone and occasionally floods.

Five wells exist at Coleman NFH. All of the wells are low producers with the best well yielding 400 gal/min. In addition to providing water for domestic purposes, these wells play an important role in hatchery production. The warm well water is used in the 15 ponds of the reuse system during critical fish rearing periods. It is tempered with cooler Battle Creek water to maintain the 57 °F water temperature required.

Even if rehabilitated, it is doubtful that the wells could produce enough water of the proper temperature and quality to satisfy hatchery needs.

Currently, geothermal reconnaissance studies are being conducted on the station by the California Division of Mines and Geology to determine the potential for underlying geothermal resources. The preliminary studies have produced sufficient significant indicators of potential geothermal resources to warrant further investigation.

Water Rights

Water rights for the use of water at the hatchery were obtained by appropriation. Present water rights are 122 ft^3/s; a table of the individual rights holders follows:

Water Rights on Battle Creek

Application No.	Permit No.	License No.	Priority date	Amount (ft^3/s)	Purpose
13540	8838	4472	01/12/50	61	Fish Culture
17862	11615	6591	10/25/57	11	Fish Culture
20288	13384	7993	07/03/61	30	Fish Culture
22277	15046	9561	07/19/65	20	Fish Culture

In order to obtain right-of-way for the water supply ditches and pipelines across private lands, it was necessary to divert and transport irrigation water for certain private lands having prior rights through the water supply system for the hatchery. These arrangements were made by Contract No. 149r-1507 dated April 10, 1944. The contract provides in part that the United States will divert from Battle Creek and carry through the fish hatchery pipeline and canal 13.13 ft^3/s of water for delivery to specified lands. This water cannot be used in the fish hatchery and reduces the amount otherwise available under the water rights by that amount when it is needed and being diverted to satisfy said prior rights. An additional 9.60 ft^3/s must also be delivered for irrigation after it has been used in the hatchery.

In order to obtain the first two water rights listed, it was necessary for the United States to enter into agreement with the appropriators who diverted below the hatchery intake and recognize that rights acquired by the Federal Government would be subject to and inferior to rights previously acquired by the appropriators. This agreement is dated July 3, 1951, and involves about 50 ft^3/s.

The FWS water rights are the lowest priority on Battle Creek, but because the use for fish culture is nonconsumptive, no other conflict with prior rights has occurred.

EXISTING FACILITIES

Coleman NFH was originally constructed in 1942. Table 6 lists the quantity, size, age, and condition of major existing facilities at the hatchery. Facility locations are described in detail in the Station Development Plan (U.S. Fish and Wildlife Service, 1984).

MAJOR SITE CONCERNS

There are a number of concerns related to Coleman NFH station development and fish production. These concerns, would have an adverse effect upon the achievement of program objectives for the hatchery. Eight major site concerns are described below.

1. Facilities Deterioration: Many facilities at Coleman are antiquated and require considerable maintenance to continue their usefulness. These include feed storage facilities, water supply systems, emergency power generating equipment, and

Table 6. Existing facilities, Coleman National Fish Hatchery. Referenced from Coleman Hatchery Station Development Plan. March 1984. p 16-21.

Facilities	Qty	Size	Year Const.	Orig. Cost	Present Cond.	Comments
BUILDINGS						
Hatchery Building (includes office space & employee room)	1	20330 sq ft	1942	97.7	Fair	Installed fluorescent lights in 1959, partial installation of false ceiling in 1979, partial replacement of windows in 1982, needs completion of rehab project.
Cold Storage Building	1	3510 sq ft	1942	43.1	Poor	Ammonia system replaced with Freon in 1972, 3 transformers installed in 1977, needs complete replacement.
Shop	1	12104 sq ft	1942	89.0	Good	Machine room enclosed in 1979, doors replaced in 1980, needs roof and paint.
Spawning Shelter	1	1076	1959	3.9	Good	Enclosed sides and added visitor platform in 1972.
Residence #14 with attached garage	1	1536 sq ft	1964	18.5	Fair	Added patio in 1970, wood burning stoves in 1982. Added windows, insulation, front door, paint in 1983.
Residence #15 with attached garage	1	1536 sq ft	1964	18.5	Fair	Added patio in 1970, wood burning stoves in 1982. Added windows, insulation, front door, paint in 1983.

Table 6 (continued)

Facilities	Qty	Size	Year Const.	Orig. Cost	Present Cond.	Comments
Residence #16 with attached garage	1	1536 sq ft	1964	18.5	Fair	Added patio in 1970, wood burning stoves in 1982. Added windows, insulation, front door, paint in 1983.
Residence #17 with attached garage	1	1536 sq ft	1964	18.5	Fair	Added patio in 1970, wood burning stoves in 1982. Added windows, insulation, front door, paint in 1983.
Residence #18 with attached garage	1	1536 sq ft	1964	18.5	Fair	Added patio in 1970, wood burning stoves in 1982. Added windows, insulation, front door, paint in 1983.
Administration Building with Visitor Area and Laboratory	1	1790 sq ft	1965	40.0	Good	
Fire Equipment and Dry Feed Storage Building	1	2016 sq ft	1965	13.1	Good	
Storage Building	1	4200 sq ft	1965	22.7	Good	
Restroom at Spawning Area	1	104 sq ft	1965	1.5	Good	
Oil Storage Shed	1	108 sq ft	1972	.7	Fair	
Storage Shed	1	74 sq ft	1972	3.5	Fair	
Restroom at Fishing Access	1	160 sq ft	1972	.9	Good	

Table 6 (continued)

Facilities	Qty	Size	Year Const.	Orig. Cost	Present Cond.	Comments
Chiller Building	1	1152 sq ft	1980	503.9	Good	
Equipment Storage Building	1	3000 sq ft	1981	22.6	Good	
FISH FACILITIES						
Raceways	28	15'x130'	1942	120.8	Good	Bottoms & head boxes recently repaired.
Incubators (Trough Type)	17	15"x16'	1942	Unknown	Poor	Need to be replaced.
Holding Pond	1	40'x205'	1950	Unknown	Good	Earthen pond remodeled with concrete sides and bottom in 1962. All existing holding ponds are inadequate for long-term holding.
Dam and Fish Ladder to Holding Ponds	1		1950	15.0	Poor	Need reinforcement of apron due to undercutting.
Holding Pond	1	36'x221'	1956	23.6	Good	
Raceways	30	8'x80'	1962	134.0	Good	Headbox and tail boards recently replaced.
Holding Pond	1	36'x220'	1965	43.0	Good	
Incubators, Vertical, Tray Type	198	16 trays	1971-1978	443.0	Good	
Fiberglass Tanks	49	4'x16'	1980	32.5	Good	
PIPELINES						
Supply Canal	2700' 3600'	46' 3'x10'	1942	120.0	Good	

Table 6 (Continued)

Facilities	Qty	Size	Year Const.	Orig. Cost	Present Cond.	Comments
Domestic Water	3000'	4"	1942	4.6	Good	
Hatchery Line	250'	18"	1942	3.0	Good	
Pond Supply	910'	18"	1942	8.0	Good	
Pond Supply	800'	24"	1945	11.8	Good	
Irrigation	300'	5"	1956	.9	Fair	
Holding Pond	400'	16"	1962	4.0	Good	
Pond Supply	4600'	48"	1964	147.4	Good	
Production Wells	1450'	12"	1964	9.6	Good	
Drain Canal	265'	3'x6'	1964	10.5	Good	
ROADS AND PARKING						
Hatchery Driveway and Parking	15,520 sq ft		1942	Unknown	Poor	Needs resurfacing and drains.
Service Roads Asphalt	88,900 sq ft		1942	Unknown	Poor	Needs resurfacing and drains. Needs gravel.
Gravel	82,000 sq ft		1942	Unknown	Fair	Needs gravel.
Fisherman Access Parking (gravel)	10,950 sq ft		1948	Unknown	Fair	Needs additional gravel.
Residence Driveways	26,135 sq ft		1942 & 1965	Unknown	Good	
MISCELLANEOUS STRUCTURES						
Well No. 1 with Storage Tank (Domestic)	1	8" dia 200' deep	1942	4.6	Good	Pump replaced in 1974.
Septic Tank and Drain Field	1	6'x6'x24' 720' Tile	1942	14.2	Good	

Table 6 (continued)

Facilities	Qty	Size	Year Const.	Orig. Cost	Present Cond.	Comments
Intake Structures Battle Creek	3	48"	1942	7.8	Fair	Modification of racks and screens on No. 2 and No. 3 needed. Diversion dam needed for No. 3.
Well No. 2	1	14" dia 120' deep	1959	14.2	Poor	Capacity reduced, contains air at times. Needs rehabilitation.
Well No. 3	1	16" dia 300' deep	1964	7.5	Poor	Capacity reduced, needs rehabilitation.
Well No. 4	1	16" dia 250" deep	1964	7.5	Poor	Capacity reduced, needs rehabilitation.
Screen Chamber	1	14" dia 400' deep	1964	20.0	Good	Screen cleaning pump added in 1967.
Incinerator	1	600,000 BTU	1965	2.0	Good	
Water Re-use System	1	6 bays, 7,500 gpm	1968-1980	1,060.2	Fair	System inadequate for needs; insufficient add water; insufficient pump capacity; inefficient bay design; need modification and expansion.
Diesel Generator	3		1975	10.5	Poor	Insufficient capacity for needs, original surplus (1943 vintage) need larger capacity & automatic transfer.

Table 6 (continued)

Facilities	Qty	Size	Year Const.	Orig. Cost	Present Cond.	Comments
Well No. 5	1		1973	19.2	Poor	Ammonia levels high (4-8 ppm). Temperature high (71 plus). Need ammonia removal system.
Pollution Abatement System	1	60'x150'	1981	214.5	Good	Additional capacity needed.

heating and cooling plants. Extended delays in rehabilitation or replacement of facilities may result in injury to hatchery personnel, loss of production, and/or acceleration in the rate of deterioration.

2. Disease: Fry and fingerlings mortality due to IHN, columnaris, furunculosis, bacterial gill disease and external parasites cause a significant loss in hatchery production. Also, salmonid whirling disease was confirmed in steelhead trout at Coleman NFH for the first time in May 1985.

3. Water Quality: The existing Battle Creek water supply carries a high sediment sand load during critical production periods. The untreated water also provides the source of infection for both bacterial and parasitic diseases.

4. Water Quantity: The existing Battle Creek intakes No. 2 and 3 do not provide sufficient water supply during low flow periods. Modification of No. 3 intake for more efficient debris removal is needed. Wells No. 2, 3, 4, and 5 are no longer capable of producing adequate water. Replacement wells are necessary to maintain production.

5. Water Temperature: Winter water temperatures are too low (42-44 °F) for effective control of the IHN virus. Summer temperatures (+60 °F) are excessive for holding winter- and spring-run chinook adult salmon.

6. Pollution Abatement Facilities: Current facilities are inadequate for efficient management of the workforce and adequate pollution control.

7. Energy Management: Energy costs are excessive for operating existing and proposed chillers for winter and spring-run salmon production. Despite preference power rates from the Western Area Power Administration, operation of various heating, chilling, and pumping systems will be extremely costly, up to $450,000 annually. Preference power electric rates provide for a maximum of 500 kW. Usage above this amount costs the prevailing high commercial rates. Efficient utilization of electrical systems and management of peak demands is essential to economically acceptable station operation.

8. Additional Production Facilities: Space in existing prerelease ponds is insufficient for rearing young salmon until they reach the desired size for release. Additional production facilities and adult holding facilities are necessary if Coleman NFH is to meet chinook salmon and steelhead trout production goals needed for maintenance of upper Sacramento River stocks.

PROPOSED DEVELOPMENT PROGRAM

The FWS has proposed a major development program needed to satisfy hatchery program objectives and resolve major site concerns (U.S. Fish and Wildlife Service, 1984). These development proposals are identified by implementation phase (initial, intermediate, and final) in the Coleman NFH Station Development Plan. A development program and estimated cost summary is provided in table 7. Intermediate and final phase proposals are dependent upon satisfactory completion of initial phase measures.

<u>Initial Phase</u>

These projects are of the highest priority and address the correction of current major problems which impair or threaten the ability of the

Table 7. Development program summary, Coleman National Fish Hatchery. Referenced from Coleman Hatchery Station Development Plan, March 1984, p. 25.

INITIAL PHASE		COST*
◦ Rehabilitate Water Supply/Treatment Facilities		$1,851,500
◦ Rehabilitate Diversion Dam		221,300
◦ Expand Pollution Abatement Facilities		209,500
	TOTAL	$2,282,300
INTERMEDIATE PHASE		
◦ Rehabilitate Hatchery Building		$ 196,900
◦ Rehabilitate Intakes 1 and 2		406,800
◦ Replace Supply Valves		104,500
◦ Construct Brood stock Holding/Spawning Facilities		715,400
◦ Construct Prerelease Ponds		1,470,400
	TOTAL	$2,894,000
FINAL PHASE		
◦ Replace Fish Food Storage Facility		$ 442,300
◦ Rehabilitate Roads and Parking Areas		87,900
◦ Improve Visitor Facilities		134,000
◦ Rehabilitate Buildings		96,300
◦ Construct Fish Protection Facilities		588,000
	TOTAL	$1,348,500
	DEVELOPMENT PROGRAM GRAND TOTAL	$6,524,800

* Cost estimates are for the 1986 construction season and based on ENR Construction Cost Index of 4,005.5 (March 1983) extrapolated at a rate of 6 percent per year and include factors for planning, engineering, and contingencies. Detailed construction drawings and cost estimates will be developed during subsequent phases of project planning and implementation and may affect costs included in this document.

station to minimally satisfy program objectives. They include rehabilitation of the water supply, water treatment, and fish diversion dam facilities and expansion of pollution abatement facilities.

Rehabilitation of the water supply and treatment facilities will entail construction of or provision for: (1) A diversion dam and sand trap to improve flows at Battle Creek intake No. 3, (2) an ozone water treatment system, (3) new wells designed to provide 5,000 gal/min of 65 °F water supplemented by a heat exchanger if necessary, and (4) standby diesel generators to ensure continuing operation of new station facilities. Detailed project descriptions and cost estimates for these and other facilities discussed in this report are provided in the Coleman NFH Station Development Plan (U.S. Fish and Wildlife Service, 1984).

Rehabilitating the Battle Creek fish diversion dam, which is severely undercut, is essential to ensure that vital brood stock needs will be obtained. Continued hatchery operations are questionable because of the present condition of this structure. Emergency action (temporary rockfill) was required in September 1984, to prevent flows from undercutting the dam. Also, modification of the fishway at the diversion dam will improve effectiveness of upstream passage for adult salmon and steelhead trout that are surplus to station needs.

Existing pollution abatement facilities are inadequate to handle production facility cleaning needs while meeting effluent discharge standards. The system is ineffective in dealing with suspended materials at the rate of operation required by hatchery staff. Coleman NFH has been unable to meet discharge permit requirements on several occasions. Development of an earthen pond (marsh) to receive cleaning waste water would ensure compliance with the discharge permit and reduce labor costs as more raceways could be drawn down simultaneously for cleaning purposes.

Intermediate Phase

These projects are second in order of priority and address mid-term efficiency and/or production conditions which may prevent Coleman NFH from substantially achieving program objectives. They include: (1) Rehabilitation of hatchery buildings, (2) rehabilitating water intakes No.'s 1 and 2, (3) replacing water supply values, (4) constructing new brood stock holding and spawning facilities, and (5) constructing four large prerelease ponds.

Final Phase

The final phase development projects are lower in priority than those projects included in the initial and intermediate phases. However, they are needed at the station to fully meet operational objectives. Final phase projects include: (1) Replacing the fish food storage facility, (2) rehabilitating roads and parking, (3) improving visitor facilities, (4) rehabilitating buildings, and (5) construction of birdproof fish protective structures.

Benefit Cost Analysis

The following is an analysis of the benefits expected to result from implementation of the development projects specified in the station development plan.

Projects needed to rehabilitate and expand fishery production at Coleman NFH will cost approximately $5.1[2] million and will generate annual net benefits to commercial and sport fishing related businesses of $1.6 million. If nonmarketed sport fishing values are also considered, net benefits will reach $5.4 million annually. Over the period of analysis, with benefits and costs expressed in present value terms, the ratio of project benefits to costs ranges from 2.5 to 6.1, depending on assumptions used. The benefits and costs identified in this report are described in detail in the Coleman NFH Station Development Plan (U.S. Fish and Wildlife Service, 1984).

COLEMAN HATCHERY ACTION PROGRAM

The BOR initiated the Coleman Hatchery Action Program (CHAP) on November 27, 1984. CHAP was originally intended to be similar in purpose to the Interim Action Measures Program being taken to accelerate resolution of fish problems at the Red Bluff Diversion Dam and the Tehama-Colusa Canal Fish Facilities. The purpose of CHAP is to assist FWS in the fishery mitigation effort at the Keswick Dam Fish Trap and the Coleman NFH.

The main goal of CHAP was for BOR to offer the technical expertise, resources, and equipment which could provide immediate solutions to ongoing problems that affected hatchery production (U.S. Bureau of Reclamation, 1985).

---

2 Present day development costs are used for the purpose of this analysis versus FY 86 projected costs used in the Proposed Development Program.

Although CHAP originally had no set expiration time, the BOR recommends that it continue throughout fiscal year 1986 with an evaluation of the progress, successes and problems at that time.

Guidelines for CHAP were:

1. Identify the problems associated with Coleman NFH and the Keswick Dam Fish Trap.
2. Determine alternate solutions and the costs of these solutions.
3. Determine which agencies have the authority/responsibility for these solutions.
4. Prioritize the actions to be taken based on the benefit/cost ratio for each action; the probability of the action being successful; and the capability to verify the actions being taken.
5. Determine a reasonable schedule for the actions to be completed.

A CHAP Steering Committee was selected with representatives from the BOR, FWS, NMFS, DFG, and the DWR. The committee met several times and identified numerous problems and alternate solutions.

These problems include:

1. Predation of migrating smolts in Red Bluff Lake and immediately below RBDD.
2. Diversion of downstream juvenile salmon into the Glenn-Colusa Irrigation District (GCID) pumps and inefficient screens.
3. Electric power costs, which are excessive for the operation of the water reuse system, the six water supply pumps, and the four water chillers.
4. The Battle Creek fish diversion dam, which is severely undercut and is subject to failure.

5. The Battle Creek Intake No. 3, which needs a sand trap and is ineffective in diverting water during low flow periods.

6. The hatchery's standby diesel generators, which are very old, worn out, and not sufficient to provide standby power for all station systems.

7. The Hatchery Building, which is in need of some repairs including: replacing deteriorated redwood incubation troughs, replacing two chiller compressors, reroofing the hatchery building, and completing the false ceiling.

8. The water supply valves for the 28, 15- by 150-feet raceways which are more than 40 years old and need to be replaced or repaired.

9. Fish depredation by egrets, herons, and kingfishers that cause a 5 percent plus loss in raceway production.

10. The existing prerelease/brood stock holding pond which has a gravel bottom. A concrete floor is needed to reduce fish mortality.

11. Inadequate existing brood stock holding facilities, which are not designed or intended for long-term holding of adult winter and spring chinook salmon.

1. To assist the migration of juvenile salmon to be released from Coleman NFH in May 1985 (per problems 1 and 2), BOR increased releases from Keswick Dam to 14,000 ft^3/s for a 3-day period from May 13-16, 1985. Over 6 million salmon smolts were released from Coleman NFH during this period. In addition, BOR operated the

RBDD gate openings in a manner to divert downstream migrating fish from the intake facilities of the Tehama-Colusa Canal (TCC) and wheeled irrigation water through the TCC to the GCID canal to reduce the amount of diversion neccessary at the GCID canal intake on the Sacramento River.

2. In regard to problem 8, the BOR offered the FWS the use of a sonic meter and operator to inspect the condition of the water supply valves. This inspection took place during June 17-18, 1985 and resulted in the conclusion that the structural integrity of the valves are acceptable and probably good for another 30 years. The only items needing attention are the rust protection paint and the gate stem packing of each valve which had deteriorated over the last 40+ years.

3. The effectiveness of Coleman NFH's Water Intake #3 was impaired because of low flows in Battle Creek (problem 5). To overcome this, BOR transported a crane and clamshell with an operator to the site on July 1-2, 1985, and placed about four truckloads of large boulders across the creek to dam up the flow below the hatchery water intake. This effort raised the flow in the creek by 9-12 inches at the intake which assures the FWS of a good water supply for the remaining summer and fall months this year.

4. During the upgrading of the water supply system for Coleman NFH, the construction of a sand trap involved movement of topsoil on a 2 to 3 acre parcel of Federal land, which in turn required an archaeological evaluation. BOR provided the services of its Regional Archeologist who made the investigation and wrote the

evaluation report. The result of this evaluation was a slight relocation of the sand trap facilities in order to preserve an archaeological site.

Most of the problems and solutions identified for Coleman NFH and Keswick Fish Trap were beyond the scope of CHAP. The Steering Committee unanimously agreed that they wanted the entire list of problems and alternate solutions, even if beyond the scope of CHAP, to be identified and presented to the Regional Director, BOR. In this way, if there was any possible way to secure funding, there would be appropriate problems and solutions already identified on which those funds could be spent.

The Steering Committee indicated that the single most needed facility at Coleman NFH is a new broodstock holding pond. To serve the needs of adult winter and spring-run chinook, a deep cool pond covered by an insulated building is necessary to hold these adult salmon through their spawning period which exists from mid-March through mid-July. The estimated cost of this facility exceeds $700 thousand (U.S. Bureau of Reclamation, 1985).

Another action item that appears beyond the ability of the CHAP but which the Steering Committee wanted pursued, is to obtain CVP project power for Coleman NFH. Because of the limited FWS Operation and Maintenance funding for Coleman NFH, the water chillers are seldom used causing undue stress during the egg incubation and rearing of juvenile winter- and spring-run chinook salmon. With the increase of energy costs and limited FWS budget, the flexibility to use the water chillers can only be regained if the FWS receives increased funding or project power is provided.

A recent Department of the Interior legal opinion (memorandum from Donald J. Barry, Assistant Solicitor, Fish and Wildlife to Assistant Secretary for Fish and Wildlife and Parks, dated December 13, 1985, subject: Central Valley Project Power and Water for the Coleman NFH) indicated there was ample legal authority for BOR to provide power to Coleman NFH, with the cost to be borne by CVP users.

To further clarify, Gary Fisher, Assistant Solicitor, Branch of Water and Power, Division of Energy and Resources, in a Memorandum dated December 27, 1985, on the subject of Coleman NFH Use of Project Power, stated that "authority was limited and [subject to the purposes and priorities established in earlier CVP authorizations and state law] Memorandum at pages 35, 46, which generally places fish and wildlife at a lower priority than other authorized project purposes."

Mr. Fisher's recommendation was to make clear "that provision of project power for Coleman NFH will be accomplished in strict conformance to the Solicitor's November 18, 1985 Memorandum which specifies that fish and wildlife purposes are subordinate and subject to other CVP uses. Existing contracts and allocations for higher priority CVP purposes will not, in summary, be abrogated."

As a result of these opinions, the Assistant Secretary for Fish and Wildlife and Parks in a Memorandum dated February 11, 1986, to the Assistant Secretary for Water and Science, pointed out two advantages for acquiring CVP resources at Coleman NFH since authority was available:

1. The cost reduction opportunities to the Federal Government in operating this mitigation hatchery are significant. Based on project power rates versus preference power rates provided to Coleman from the Western Area Power Administration (WAPA), cost

avoidances are estimated to be $90,000 per year by 1994. If the existing contract for 500 kW at preference power rates is not renewed by WAPA in 1994, cost projections from investor-owned utilities in California indicate that savings of up to $360,000 per year would be realized from project power.

2. The recent outbreak of disease at the Coleman NFH has induced the Fish and Wildlife Service to consider instituting more stringent disease-control measures in the hatchery's water supply. Although only preliminary investigations have been completed, it is already clear that even the least efficacious alternative will be energy-intensive, and thus cost more than present fiscal resources could bear. Project cost of additional power to accommodate the necessary disease-control systems would be $127,500 per year, rising to another $330,000 per year by 1994.

WHIRLING DISEASE

Salmonid whirling disease was confirmed in steelhead trout at Coleman NFH for the first time in May 1985. The causative agent of whirling disease is Myxosoma cerebralis, a protozoan parasite. Severe infections in young steelhead trout may cause death. Survivors may develop a "black tail" condition, whirling behavior (i.e., swimming in circles), and/or skeletal deformities such as twisted spines and deformed heads.

Steelhead trout fingerlings (Brood Year 1985) from Coleman NFH rearing ponds were collected and examined for the presence of M. cerebralis spores. Although nearly 75 percent of the fish that were processed and examined by microscope tested positive for M. cerebralis spores, only 0.01 percent of the fish individually examined for external signs of whirling disease showed any skeletal deformities.

Water from Battle Creek, which supplies the hatchery, was suspected to be the source of M. cerebralis. An extensive monitoring program was begun to determine if an infectious cycle had been established in the main water supply. In addition, more than 500 wild rainbow trout were collected and examined from thirteen different locations in the Battle Creek drainage. The results showed that M. cerebralis is well established in the Battle Creek drainage (Christopher M. Horsch, Coleman Fish Health Center, pers. comm). Other surveys have shown that whirling disease is widespread in California.

The Regional Office of the U.S Fish and Wildlife Service has subsequently decided that the infected steelhead trout from Coleman NFH would not be stocked in Battle Creek or the Sacramento River, where they would have access to the ocean and possibly to the Northwest rivers of British Columbia, Idaho, Oregon, and Washington. Releasing them could have led to the spread of whirling disease to uninfected steelhead stocks elsewhere in the Northwest.

The future for steelhead trout production at Coleman NFH is uncertain. During the fall of 1985, more than 2,500 adult steelhead trout migrated into the hatchery. These adults are the source for the Brood Year 1986 steelhead eggs. There is concern that when these eggs hatch, the fry will be exposed to the M. cerebralis spores in the hatchery water supply, and contract whirling disease. Two alternatives being considered are: (1) rearing these eggs and fry in well water or ozone-treated water to reduce their exposure to M. cerebralis; and

(2) rearing these eggs and fry at the Tehama-Colusa Canal Fish Facilities, where whirling disease has never been found.

The Coleman NFH Station Development Plan (U.S. Fish and Wildlife Service, 1984) includes proposals for projects to satisfy hatchery program objectives and resolve major site concerns. One of the highest priority projects is the rehabilitation of the water supply/treatment facilities. Installation of a sand trap and an ozone water treatment system would significantly reduce whirling disease as well as other disease-caused mortalities of young fish. Due to the severity of the whirling disease problem, Congress has appropriated the additional money needed for the water supply/treatment facilities at Coleman this fiscal year (U.S. Fish and Wildlife Service, 1986). This is a partial fulfillment of the Initial Phase of the Station Development Plan.

PART III

KESWICK FISH TRAP

OPERATIONAL HISTORY

The facilities for trapping adult fish at Keswick Dam and transferring them to Coleman NFH consist of a 12-step fishway, a sweep bay, a brail-lift and a 1,000-gallon fish-tank elevator. The facilities are located in the center of the dam between the powerhouse and the spillway and are designed to operate at riverflows up to approximately 16,000 ft^3/s (figure 4). Construction of the trap commenced in the fall 1941, and temporary facilities for operation of the trap were completed by June 1, 1943 (Needham, et al., 1943).

The primary objective of this facility was to trap spring-run and other races of chinook salmon crowded below Keswick Dam for relocation elsewhere or for artificial propagation at Coleman NFH. During June 1943, over 5,000 chinook were trapped and taken to Deer Creek near Vina. These included both spring- and winter-run races (Hallock, California Department of Fish and Game (retired) pers. comm., 1984). Between 1943 and 1946, nearly 20,000 salmon were trapped at Keswick and transported (table 8). During this period, modifications were made to improve trap operation and reduce adult mortality. These included installation of stoplogs and controls at the end of the fishway, improvements to the loading hopper, and construction of a brail in the hopper chamber to salvage fish. The greatest number of salmon handled in

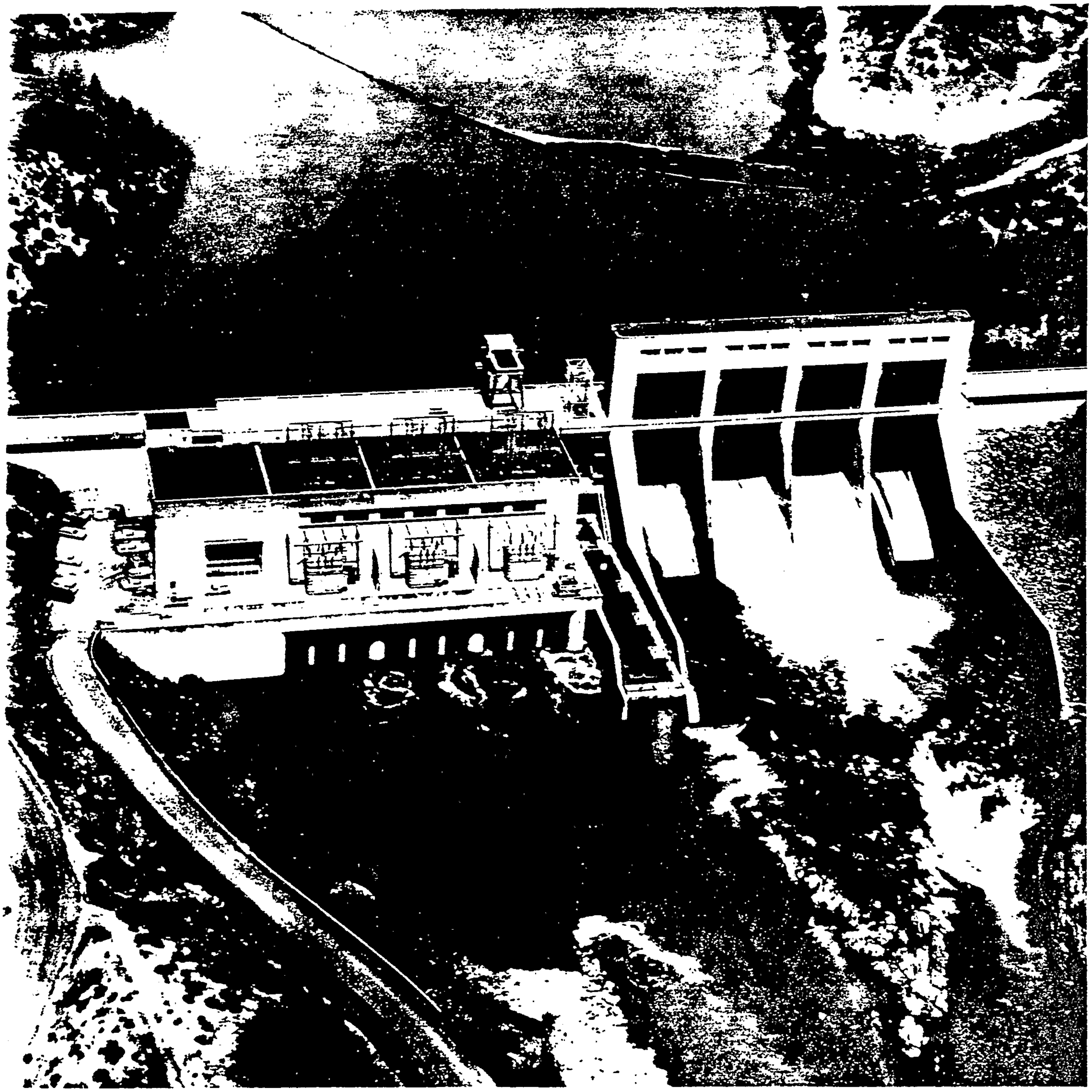


Figure 4. Keswick Dam and Fish Trap.

Table 8. Chinook salmon trapped at Keswick Fish Trap. 1943-1984. Referenced from Annual Report, Coleman National Fish Hatchery, 1943-1984.

Year	No trapped	Race*	Disposition
1943	6,334	SCS	944 to Battle Creek, remainder to Deer Creek
1944	2,209	SCS	Deer and Battle Creeks
1945	894	SCS	Deer and Battle Creeks
	320	FCS	Battle Creek
1946	2,391	SCS	Deer and Battle Creeks
	7,536	FCS	Battle Creek
1947	0		
1948	102	FCS	Coleman NFH-trap check
1949	0		
1950	1,149	FCS	Coleman NFH
1951	3,008	FCS	Coleman NFH
1952	4,661	FCS	Coleman NFH
1953	1,428	FCS	Clear Creek
	6,793	FCS	Coleman NFH
1954	5,907	FCS	Coleman NFH
1955	1,003	FCS	Clear Creek
	502	FCS	Shasta Lake
	4,945	FCS	Coleman NFH
	184	WCS	Coleman NFH (released)

* SCS = Spring chinook salmon
FCS = Fall chinook salmon
LFCS = Late-fall chinook salmon
WCS = Winter chinook salmon

Note, 1943-1962 reported as calendar year totals
1963-to date reported as fiscal year totals

Table 8 (continued)

Year	No trapped	Race	Disposition
1956	2,661	FCS	Coleman NFH
1957	9,229	FCS & LFCS	Coleman NFH
1958	13,517	FCS & LFCS	Coleman NFH
	425	SCS	Battle Creek
	420	WCS	Coleman NFH
1959	7,566	FCS & LFCS	Coleman NFH
	4,334	WCS	Sacramento River and Battle Creek
1960	9,783	FCS & LFCS	Coleman NFH
	580	WCS	Sacramento River and Battle Creek
1961	5,647	FCS & LFCS	Coleman NFH
	2,780	WCS	Sacramento River below ACID
1962	15,187	FCS & LFCS	Coleman NFH and Battle Creek
	214	WCS	Coleman NFH and Battle Creek
1963	5,125	FCS & LFCS	Coleman NFH
	53	WCS	Coleman NFH
1964	3,861	FCS & LFCS	Coleman NFH
1965	2,906	FCS & LFCS	Coleman NFH
	22	WCS	Coleman NFH
1966	3,981	FCS & LFCS	Coleman NFH
	7	WCS	Coleman NFH
1967	4,400	FCS & LFCS	Coleman NFH
	15	WCS	Coleman NFH
1968	1,551 (plus 2,397 from ACID trap)	FCS & LFCS	Coleman NFH
1969	4,363	FCS & LFCS	Coleman NFH

Table 8 (continued)

1970	4,041	FCS & LFCS	Coleman NFH
1971	2,190	FCS & LFCS	Coleman NFH
1972	403	LFCS	Coleman NFH (return from '69 copper kill)
1973	705	LFCS	Coleman NFH (trap flooded)
1974	2,066	LFCS	Coleman NFH
1975	975	LFCS	Coleman NFH
1976	2,564	LFCS	Coleman NFH and Battle Creek
	293	SCS	Tributaries below Redding
1977	1,853	LFCS	Coleman NFH and Battle Creek
1978	829	LFCS	Coleman NFH
	63	WCS	Coleman NFH
1979	867	LFCS	Coleman NFH
1980	2,065	LFCS	Coleman NFH
1981	1,300	FCS	Coleman NFH
	1,745	LFCS	Coleman NFH
	57	WC	Coleman NFH
1982	93	FCS	Coleman NFH
	432	LFCS	Coleman NFH
1983	212	FCS	Coleman NFH
	181	LFCS	Coleman NFH
1984	207	LFCS	Coleman NFH

1 month during this period occurred in November 1946, when 7,536 fall-run chinook were trapped at Keswick following the washout of the Balls Ferry rack.

Based upon a declining number of spring chinook entering the Keswick trap due to favorable water temperatures in the Sacramento River by 1945 and 1946, and a determination made by the FWS that this run of salmon was more likely to be perpetuated if left undisturbed in the river, trapping operations ceased at Keswick from 1947 through 1949 (U.S. Fish and Wildlife Service, Coleman NFH annual production reports, 1945-50). During these years, arrangements were made with the Anderson-Cottonwood Irrigation District (ACID) to block all chinook salmon runs at the ACID Diversion Dam in Redding. This action, however, forced the spring run of chinook to spawn in an area where subsequent fall run spawning activity reduced survival of incubating eggs and larvae, thereby decreasing the spring-run (Hallock, California Department of Fish and Game (retired), pers. comm., 1984).

Since 1950, the Keswick Fish Trap has been used by the Coleman NFH to obtain brood stock for supplemental fish production, primarily fall- and late fall-run chinook salmon. Spring-run chinook have not been propagated at Coleman NFH since 1951 due to insufficient cool water at the hatchery. Winter-run chinook salmon accumulated below Keswick Dam are occasionally collected for limited propagation, but success has been poor because of high incubation and rearing temperatures experienced at the hatchery during spawning and incubation periods (U.S. Fish and Wildlife Service, Coleman NFH annual production reports, 1951-80).

During the 1950's, fall- and late fall-run chinook salmon were collected at the Keswick Fish Trap, providing approximately one-third of Coleman NFH's salmon egg supply. Annual numbers of salmon trapped for the hatchery ranged from 1,149 to 13,517, with an annual mean of 6,000 fish. The trap was operated primarily from mid-November through January.

In the 1960's, the Keswick facility was providing about one-half of Coleman's chinook salmon egg supply. Trap operations were extended later in the season with the objective of collecting more late fall-run chinook and relocating winter-run chinook salmon. The winter-run chinook were released in the Sacramento River downstream from the ACID Diversion Dam where suitable spawning gravel was plentiful. Annual numbers of fall-run and late fall-run chinook salmon trapped for the hatchery during this period ranged from 1,240 (1968) to 15,876 (1962) and averaged about 5,600 fish. Adult fishkills at Keswick Fish Trap were noted on several occasions during the 1960's, the worst occurring in 1969. These kills were caused by acid mine wastes and dissolved metals, principally copper and zinc, discharging into Keswick Lake from Spring Creek.

Salmon trapped at Keswick declined significantly, during the 1970's, ranging from 4,041 (1970) to 403 (1972) with a mean of 1,650 fish annually. Trapping operations usually commenced in December. Nearly all of the salmon collected were late fall-run chinook. The reasons for the decline of salmon available for trapping at the Keswick facility during the past decade have been attributed to several factors including: (1) Degradation of the upper Sacramento River salmon spawning grounds due to reduced gravel recruitment and riverbed armoring, (2) fishkills resulting from heavy metal discharges from Spring Creek, (3) unfavorable flow releases, and (4) adverse effects of the RBDD (Hayes, 1978). In several years (1970, 1971, 1974, and 1978) high sustained discharge from Shasta Dam precluded operation of the Keswick facility for significant periods of time. Operation of the fish trap at Keswick Dam is impaired at releases exceeding 16,000 ft^3/s. The fishway and trap become flooded and completely inoperable at releases exceeding 19,000 ft^3/s.

CURRENT STATUS

The Keswick Fish Trap is presently used to collect fall- and late fall-run chinook salmon migrating up the Sacramento River. These fish are transported to Coleman NFH by truck for artificial propagation. Trapping usually occurs from November through February (figures 5-10). It is anticipated that winter- and spring-run chinook will also be collected at Keswick for propagation at Coleman NFH in the near future. Few salmon appear to ascend the ACID dam fishway during the irrigation season (April to November), thus limiting the numbers of winter- and spring-run chinook potentially available.

Several operational programs restrict the efficiency of the Keswick Fish Trap. These include high releases from Keswick Dam, poor attraction flow into the fishway, and occasional adult fishkills from toxic heavy metal discharge into Keswick Reservoir or failure to deactivate the trap at the onset of high flood control releases.

Periods of continuous high releases in 1969, 1970, 1971, 1974, 1978, 1981, and 1982 restricted trapping and significantly reduced the late

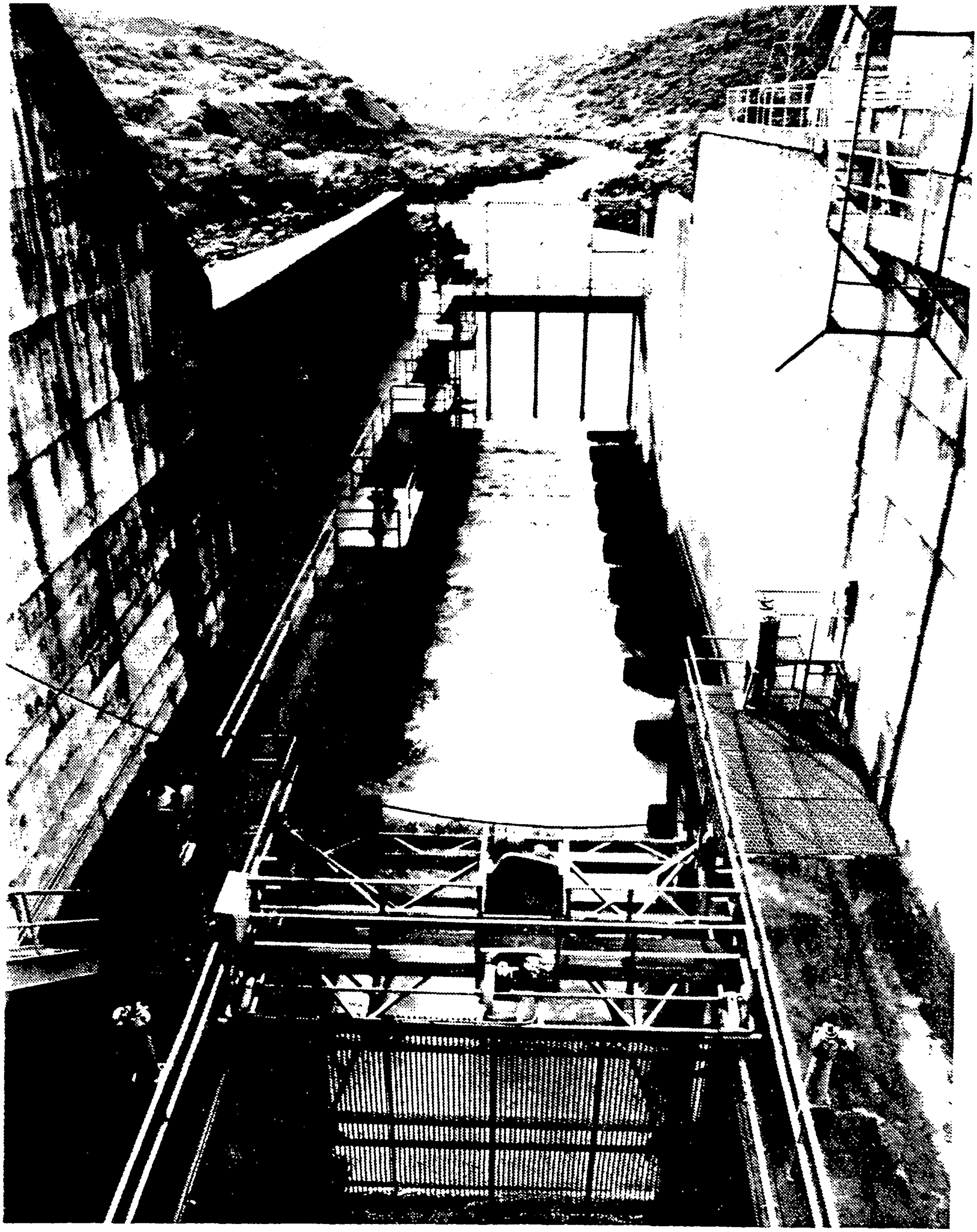


Figure 5. Downstream view of Keswick Fish Trap fishway. The fishway becomes inoperable due to flodding at approximately 19,000 ft^3/s riverflow passing Keswick Dam.

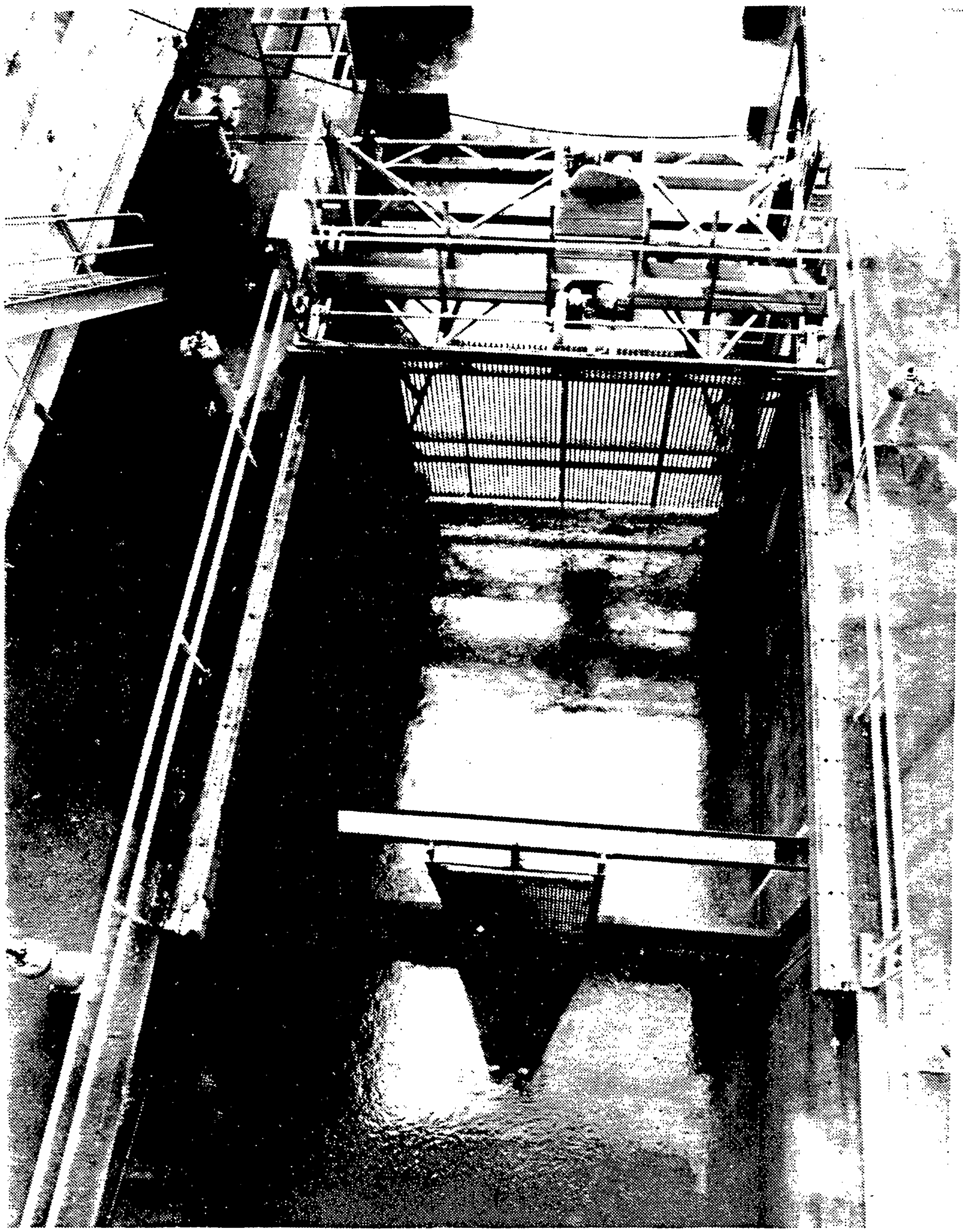


Figure 6. Downstream overhead view of the head of the Keswick fishladder. The sweep bay is in the middle third on the photograph, the brail lift is in the bottom third of the photograph.

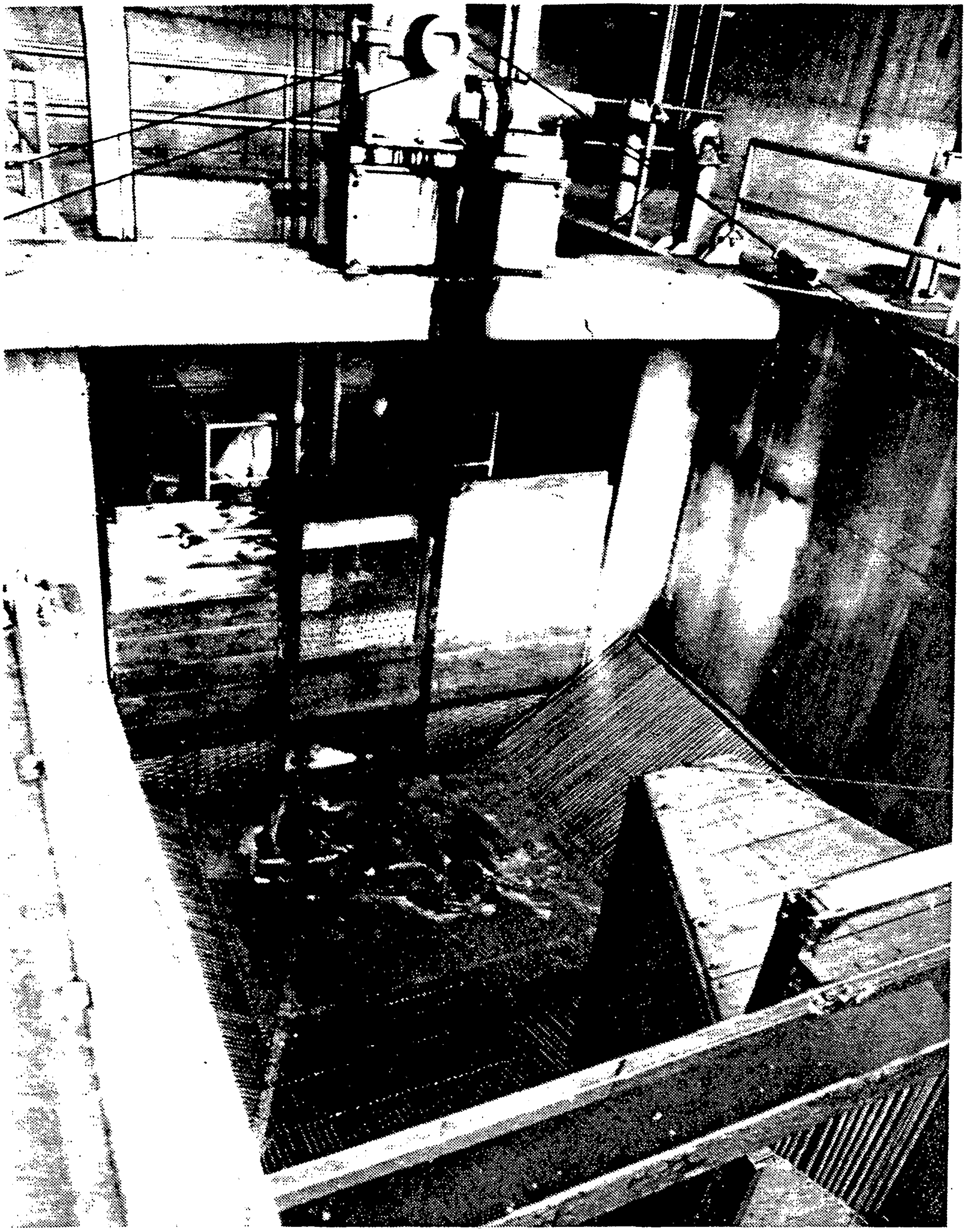


Figure 7. Upstream view of fish entering the 1,000 gallon fish tank at Keswick Fish Trap. The brail lift is in the up position, out of the water. The trapped fish are being directed into the fish tank. Fish are counted as they swim over a white flashboard at the fish tank entrance.

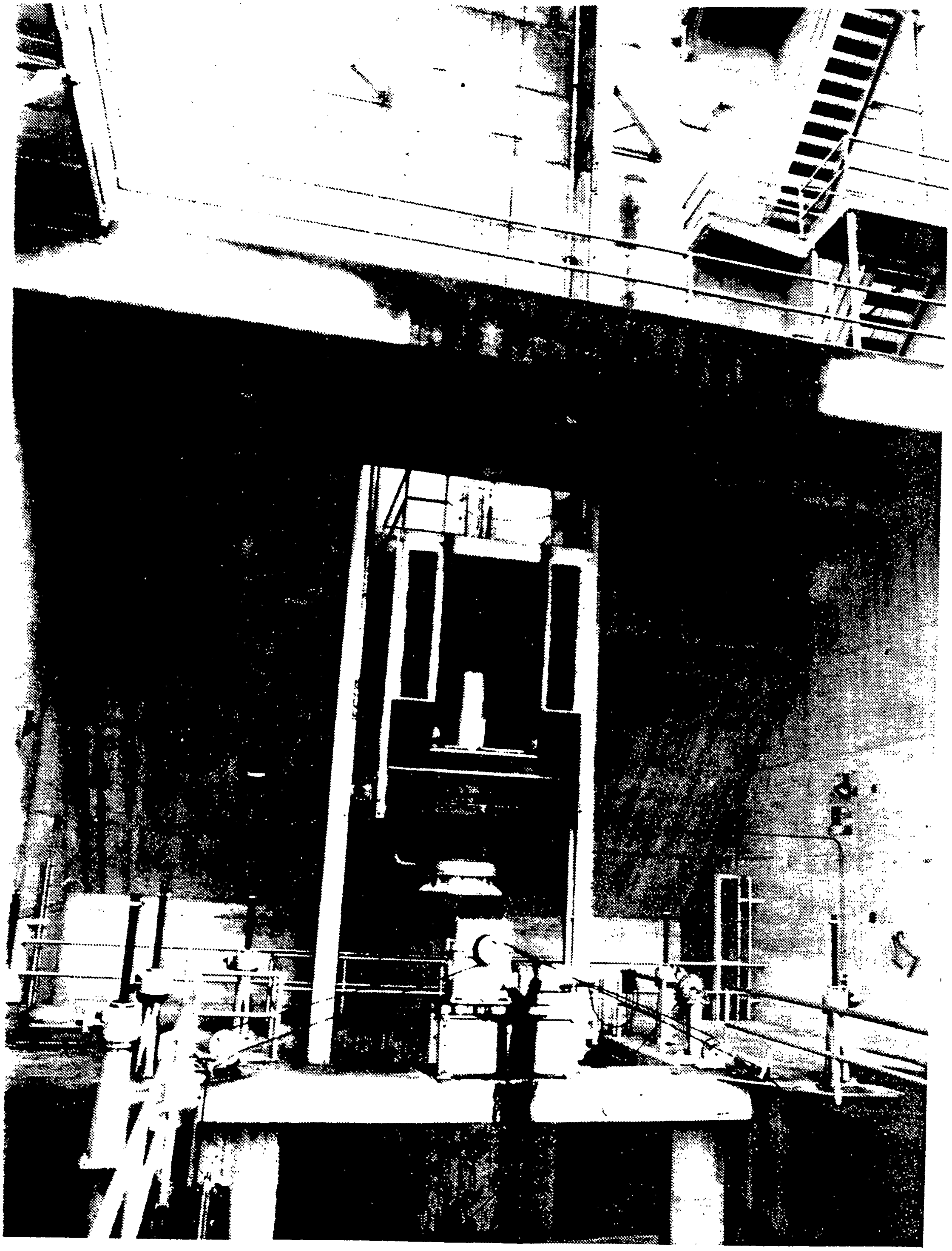


Figure 8. Fish tank elevator being lifted to the loading platform at Keswick Dam.

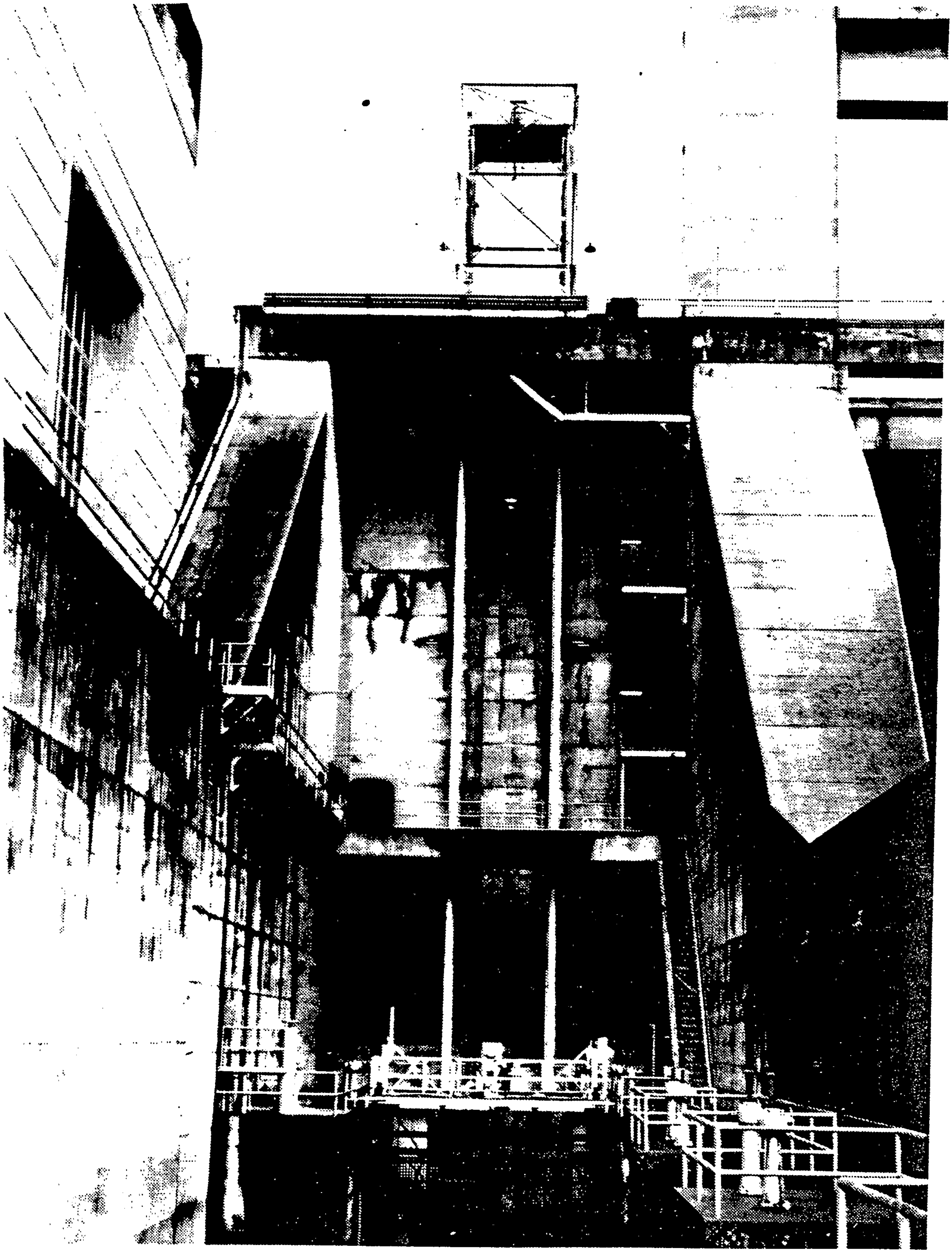


Figure 9. Fish tank elevator structure at Keswick Dam.

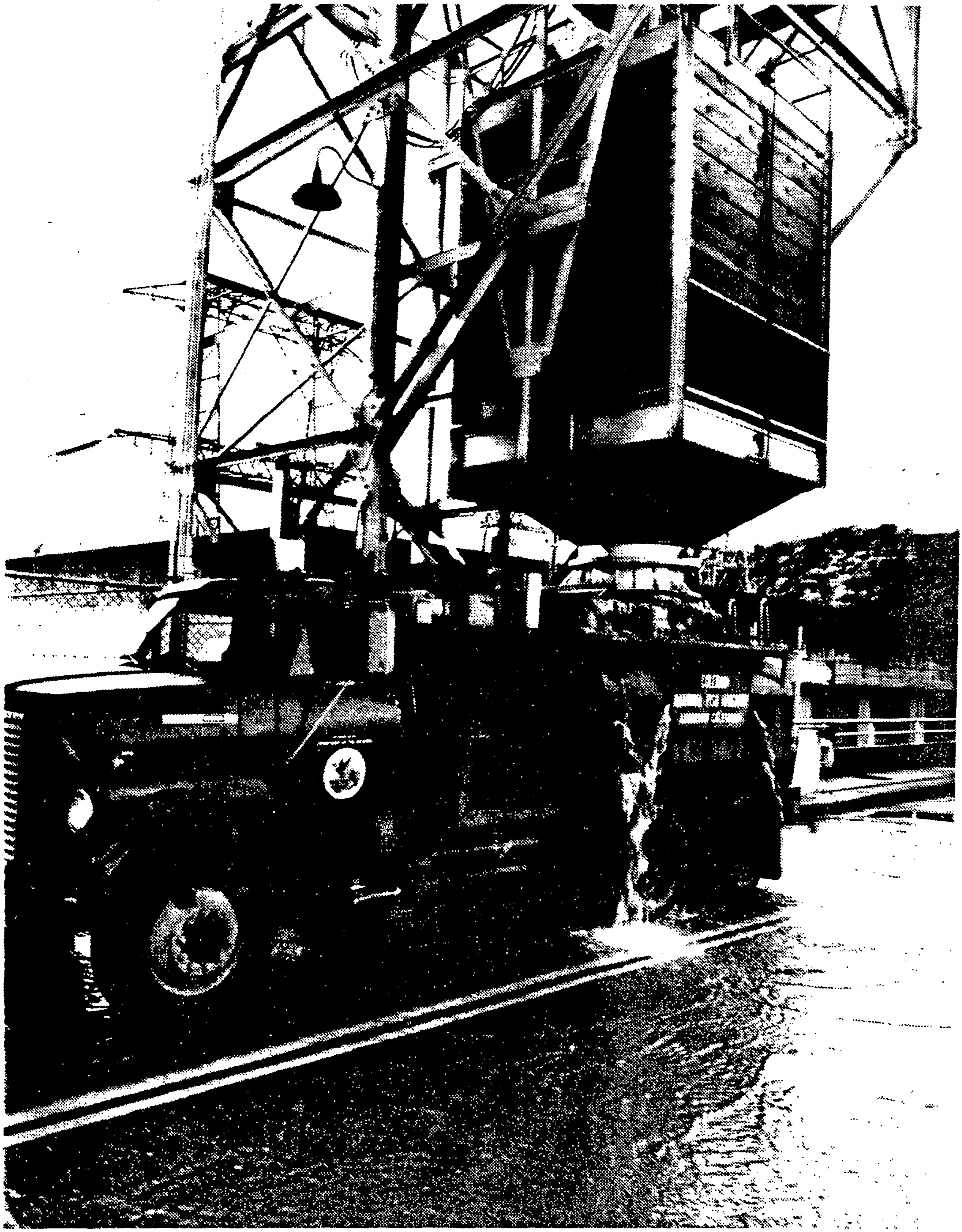


Figure 10. Transfer of fish from the elevator to the fish truck. These fish will be transported to Coleman National Fish Hatchery (the truck is loaded atop Keswick Dam).

fall-run egg take for Coleman NFH. High turbulence and lack of resting area below Keswick Fish Trap and adjacent spillway during periods of high discharge result in salmon loss from injury, exhaustion and failure to spawn successfully (U.S. Fish and Wildlife Service, 1971). The need for corrective action was presented in a 1971 report to the California Legislature by the Citizens Advisory Committee on Salmon and Steelhead Trout (California Legislature, 1971). The Committee recommended that the Federal Government make the necessary alterations in the design or operations of Keswick Fish Trap to assure its efficient operation at the time of all salmon runs.

The FWS offered three possible solutions for the BOR's consideration (U.S. Fish and Wildlife Service, 1971):

1. Revise release schedules during extended flood control releases to reduce flows to below 19,000 ft^3/s for several hours every third day to allow capture of a 3-day accumulation of fish,
2. Extend the wall separating the fish ladder from the spillway at Keswick to provide holding and resting area for fish during high water releases and reduce flows twice a week to permit fish to ascend the ladder and enter the trap, and
3. Reconstruct the Keswick ladder and trapping facilities to permit fish collection at greater water releases than 19,000 ft^3/s.

The BOR's response to these recommendations (U.S. Bureau of Reclamation, 1971) was to reject the concept of periodic flow reductions but investigate the feasibility of structural modifications to permit fish collecting at flows exceeding 19,000 ft^3/s. Periodic flow reductions during high releases would aggravate downstream erosion and violate flood control regulations established by the Corps of Engineers.

A detailed report by the NMFS (National Marine Fisheries Service, 1971) outlined the modifications necessary to provide fish trap and ladder operations at flows up to 55,000 ft^3/s. The BOR estimated that a 320-foot extension of the wall separating the spillway and fishway would cost $330,000 and a 10-step ladder extension would cost $540,000 with possible loss in power generation.

Based on the NMFS report, the FWS recommended to BOR (U.S. Fish and Wildlife Service, 1972) that the following changes be implemented:

1. Install entrance gates to control the flow of water from fishway entrance;
2. Return auxiliary water diffusers to operable condition;
3. Modify hopper to improve method of transferring fish from hopper to truck;
4. Raise nonoverflow sections of weirs to improve flows in fish ladder during higher flows;
5. Replace holding pool picket barriers.

The FWS also supported the accomplishment of modifications recommended by the NMFS which would facilitate effective fish trapping operations at releases to 55,000 ft^3/s. However, further investigations indicated there was insufficient justification to support major structural alterations at Keswick Dam (memorandum, February 1973, from Director, Bur. Sport Fish. and Wildlife, Portland, OR, to Director, USBR, Sacramento, CA; Subject: Fish Trap Rehabilitation and Funding - Keswick

Dam; and letter February 1, 1973, from Director, Bur. Sport Fish. and Wildlife, Portland, OR, to Director, DFG, Sacramento, CA). Some minor modifications were made, but none that resulted in the Keswick Fish Trap working effectively at flows greater than 16,000 ft^3/s.

Fish attraction flow into the Keswick fishway leading to the trap structure is augmented by water released from floor diffusors in the upper, middle, and lower sections of the fishway (figure 10). There is a tendency for the grating to plug with debris, thereby reducing attraction flow.

Serious adult fishkills have occurred in the holding facility of the Keswick Fish Trap because of toxic mining effluent discharging into Keswick Lake from Spring Creek. The most significant kills occurred in 1955, 1960, 1969, and 1981. During high runoff periods in January, elevated concentrations of copper and zinc in Keswick Dam releases caused the death of several hundred adult salmon. This problem and potential solutions are addressed in Problem No. C-1 of the CVFWMS.

Another problem associated with operation of the Keswick Fish Trap occurs when the trap cannot be deactivated prior to discharge of unscheduled or unexpected high releases from Keswick Dam for flood or water-quality control purposes. These releases must be made so rapidly that sufficient advance notification cannot be made. Tailrace water levels flood the trap structure, including the stem gate valve handles, and fish trapped in the holding pond cannot be released. Often, the jet pump discharging into the trap is turned off during high flows. Consequently, adult fish are subjected to varying periods of confinement in unfavorable flow conditions which occasionally results in mortalities. Also, adult chinook may become trapped in the spillway adjacent to the fish trap facility when flows are reduced.

Recent BOR investigations presented several suggestions which would increse fish trap operational efficiency and decrease the occasional incidence of fishkills at Keswick Fish Trap (U.S. Bureau of Reclamation, 1982). These measures include:

1. Relocation of the winch, which operates the hopper gate, to the top of the walkway and machinery gate.
2. If possible, a 3-hour notification period will be given to the FWS prior to increasing flows beyond operational capabilities of Keswick Fish Trap.
3. The brail shall be left "up" after the final trapping preceding high flood releases. FWS will be notified when releases are subsequently reduced.
4. The jet pump should remain on until all fish have been removed.
5. The BOR's Shasta Office (CVP) staff will confer with Coleman NFH personnel, to determine at which releases problems occur. A recommendation will be made as to what modification may be needed. A staff gauge will be installed to facilitate obtaining measurements.
6. The BOR Regional Office dive team will inspect diffusers to determine their status.

7. After it is determined at what flows problems begin to occur, steps will be taken to modify the Standard Operating Procedures as needed.

8. Initiate necessary protective actions in consultation with DFG and FWS to prevent loss of fish stranded in the spillway basin at the base of Keswick Dam during low flow periods.

Under new trial operations, the BOR, in cooperation with Coleman NFH, is attempting to further improve fish trap operations at Keswick Fish Trap (U.S. Bureau of Reclamation, 1983). When the hatchery requires brood stock, BOR will leave the trap in operation as much as possible. At flows up to 20,000 ft^3/s, the trap will remain in operation and, at time of fish transfer, flows may be decreased to 17,000 ft^3/s for 1 hour for fish removal. At higher flows between 20,000 ft^3/s to 36,000 ft^3/s, BOR will reduce flows (within operational constraints of Keswick Dam) to 17,000 ft^3/s for short periods to facilitate fish removal and trap deactivation. Deactivation would consist of turning off the attraction water and raising the brail hoist. If for any reason fish remain in the brail hoist pool and releases exceed 20,000 ft^3/s, attraction water will be maintained to aerate the brail pool and prevent fishkills. These trial operations appear to have resolved some of the problems experienced in the past and have resulted in improved commmunications between the BOR and Coleman NFH personnel.

PART IV

SUMMARY OF FINDINGS AND CONCLUSIONS

FINDINGS

Coleman National Fish Hatchery

Hatchery operation and maintenance costs were transferred from the BOR to the FWS as the result a memorandum of agreement between the two agencies executed in 1948. The agreement was based, among other factors, on the apparent successful establishment of levels of salmon runs downstream from Shasta Dam equivalent in number to those displaced upstream from Shasta Dam.

There are a number of problems preventing successful operation of Coleman NFH. These problems generally include the repair or replacement of outmoded or wornout facilities and equipment and the installation/ construction of new facilities and equipment not originally included in the planning for the hatchery.

The single most needed new facility at Coleman NFH is an adult broodstock holding pond for winter and spring-run chinook salmon. The proposed facility consists of a deep, cool pond covered by a weather-insulated building.

The water supply is inadequate for full potential development of chinook salmon and steelhead trout production. Battle Creek water has a high sediment (sand) load during critical production periods, is a source of potential bacterial and parasitic diseases, and affords insufficient water temperatures (the water is too cold in the winter and too warm in late spring and early summer to provide disease control and favorable growth rates).

The energy costs are excessive for operating existing and proposed chillers for winter- and spring-run salmon production. The preference power electric rates provide for a maximum of only 500 kW; usage above this amount costs the prevailing high rates. Associated with the high energy costs for chiller operation is the potential fish loss due to mechanical failure.

Space in prerelease ponds is insufficient to rear young salmon to the desired release size. Similarly, there are insufficient brood stock holding and spawning facilities to meet the hatchery production goals.

The feed storage facility, water supply and treatment systems, emergency power generating equipment and heating and cooling plants are obsolete. The number of juvenile prerelease ponds and adult holding ponds is insufficient. The fish diversion dam and fishway structure at Battle Creek are inadequate; the existing structure is seriously eroded and undermined and is in danger of failing. Numerous other facilities are in deteriorated condition or simply outdated, including hatchery buildings, roads, parking areas, and visitor facilities.

Existing pollution abatement facilities are inadequate to handle facility cleaning needs while meeting effluent discharge standards.

Fingerlings continue to be lost to a variety of diseases. These diseases include Infectious Hematopoietic Necrosis (IHN), columnaris, furunculosis, bacterial gill disease and external parasites.

Salmonid whirling disease was confirmed in steelhead trout at Coleman NFH for the first time in May 1985. This infectious disease is caused by a waterborne parasite endemic in the water supply from Battle Creek. The disease may cause death, skeletal deformities, and erratic swimming behavior in infected fish. This disease is serious enough that the distribution of fish reared at Coleman NFH has been curtailed.

Knowledge on optimum release sites, timing and size of releases of Coleman NFH chinook salmon and steelhead trout is insufficient. Numerous evaluations are being conducted by FWS and DFG to better define these factors.

Future developments which may present additional problems at Coleman NFH include increased operating expenses resulting from higher energy costs which would reduce the efficiency of the hatchery operations; the proposed hydroelectric powerplants at RBDD, ACID, and Battle Creek may further impact migration and survival of hatchery fish by increasing water diversion above and below the hatchery; the effect of increased commercial and sport fishing effort on hatchery stocks could reduce the size of the stocks; and Sacramento-San Joaquin Delta water facilities and operations and other water project development could negatively affect the survival of the young hatchery produced fish.

Keswick Fish Trap

1. The trapping facilities are inefficient at flows exceeding 16,000 ft^3/s and inoperable at flows exceeding 19,000 ft^3/s.
2. Lack of sufficient attraction flow into the fishway restricts the efficiency of the Keswick Fish Trap operation.

3. Occasional fishkills in the trap facility result from acid mine waste discharge and operational constraints during high flow periods. The latter problem occurs when increased releases at Keswick dam prevent FWS personnel from lifting and removing trapped fish from the trap structure. New operating procedures and minor modifications appear to have resolved this problem, however.
4. Poor fish passage facilities at ACID Dam prevent the salmon from migrating upstream to the Keswick Fish Trap.
5. Adult salmon perish when they become trapped in the spillway basin adjacent to the Keswick Fish Trap facility.

CONCLUSIONS

The BOR should endorse the efforts of the FWS and assist in securing funding for facilities modifications required to meet mitigation responsibilities at both Coleman NFH and the Keswick Fish Trap.

Coleman National Fish Hatchery

1. The need for revising the 1948 Memorandum of Agreement between the BOR and the FWS regarding operation and maintenance of Coleman NFH should be assessed in view of the deterioration of salmon and steelhead runs resulting from long-term impacts of Keswick and Shasta Dams.
2. Energy usage at Coleman NFH should be thoroughly evaluated. Energy conservation measures and reduced electrical power rates for all essential hatchery operations should be included in an overall energy program for the hatchery. Less expensive

alternative power sources (including CVP project-use electrical power), and modifications of hatchery operations to reduce energy dependency, should be sought.

3. New water sources should be developed to provide an additional 5,000 gal/min to the station.
4. Existing water supply and treatment facilities should be rehabilitated.
5. Additional rearing facilities, including four large prerelease ponds, should be constructed.
6. The existing diversion dam and fishway in Battle Creek should be rehabilitated.
7. A new fish food storage facility should be constructed.
8. Deteriorated hatchery buildings, roads and parking areas should be rehabilitated.
9. A new holding pond facility should be constructed. It should be covered by an insulated building for adult winter and spring-run chinook salmon.
10. The pollution abatement facilities should be expanded by constructing an earthen pond to receive cleaning waste water.
11. The results of the Coleman NFH production evaluations under the direction of FWS and DFG should be incorporated in future management of the hatchery.
12. Methods for control of IHN virus should be developed.
13. Solutions to salmonid whirling disease should be implemented. Alternative solutions include: replace the Battle Creek surface

water supply with well water at Coleman NFH to rear steelhead eggs and fry; rear steelhead eggs and fry at the Tehama-Colusa Canal Fish Facilities; or, install a sand trap and an ozone water treatment system at the Coleman NFH.

14. New brood stock holding and spawning facilities should be constructed to meet hatchery production goals.

15. The visitor facilities should be upgraded.

Keswick Fish Trap

1. Fishkills at Keswick trap caused by unscheduled high releases should be eliminated by close communication and coordination between the staffs of FWS (Coleman NFH) and the BOR (Shasta-Keswick Operations) regarding operation of the trap and modifications to the trap control system to allow the trap to be operated efficiently at flows in excess of 16,000 ft^3/s.

2. The potential for increasing the operational capability of the Fish Trap at flows greater than 16,000 ft^3/s should be reassessed.

3. Fish passage at ACID diversion dam should be improved to allow free movement upstream of migrating adult chinook salmon.

4. Trapping of fish at ACID Dam as an alternative to the Keswick Fish Trap Dam should be studied by BOR if the city of Redding does not build the proposed powerplant at that dam.

REFERENCES CITED

Azevedo, R. L., and Z. E. Parkhurst, 1957. The Upper Sacramento River and Steelhead Maintenance Program, 1949-1956. Fish and Wildlife Service Office Report, 96 pp.

California Department of Fish and Game, 1984. Letter to Dave Houston, Regional Director, Bureau of Reclamation, from H. D. Carper, Director, CDFG, with enclosed reports on salmon and steelhead declines attributable to Red Bluff Diversion Dam.

California Legislature, 1971. An Environmental Tragedy. Report on California Salmon and Steelhead Trout (authorized by Assembly Concurrent Resolution #64/1970 Session), 40 pp.

Calkins, R. D., W. F. Durand, and W. H. Rich, 1940. Report of the Board of Consultants of the Fish Problems of the Upper Sacramento River. Stanford University, June 21, 1940, 34 pp. and appendix.

Cope, O. B., and D. W. Slater, 1957. Role of Coleman Hatchery in Maintaining a King Salmon Run. Research Report 47, Fish and Wildlife Service, U.S. Government Printing Office, 22 pp.

Hanson, H. A., O. R. Smith, and P. R. Needham, 1940. An Investigation of Fish-Salvage Problems in Relation to Shasta Dam. U.S. Department of the Interior, Bureau of Fisheries. Special Scientific Report No. 10, 199 pp.

Hallock, R. J., 1980a. Returns From Coleman Hatchery Steelhead Trout Released at the Hatchery and at Rio Vista. CDFG, Anadromous Fisheries Branch Office Report, October 15, 1980, 5 pp.

Hallock, R. J., 1980b. Returns From Coleman Hatchery Steelhead Trout Released in December and February. CDFG, Anadromous Fisheries Branch Office Report, January 23, 1980, 3 pp.

Hallock, R. J., 1980c. Returns From Steelhead Trout Released as Yearlings at Coleman Hatchery and below Red Bluff Diversion Dam. CDFG Anadromous Fisheries Branch Office Report, January 18, 1980, 3 pp.

Hallock, R. J., R. R. Reisenbichler, and J. D. McIntyre, 1980. Relation Between the Size of Chinook Salmon Released at Hatcheries, and Returns to the Ocean Fisheries and Hatcheries. CDFG Anadromous Fisheries Branch Office Report, Revised May 15, 1980, 11 pp.

Hallock, R. J., and R. R. Reisenbichler, 1979. Evaluation of Returns from Chinook Salmon Released as Fingerlings at Coleman and Nimbus Hatcheries and in the Sacramento River Estuary. CDFG, Anadromous Fisheries Branch Office Report, Revised August 22, 1979, 10 pp.

Hallock, R. J., W. F. Van Woert, and Leo Shapovalov, 1961. An Evaluation of Stocking-Reared Steelhead Rainbow Trout in the Sacramento River System. CDFG Fish Bulletin, No. 114, 74 pp.

Hayes, J., 1978. Declining Salmon Runs. CDFG Issue Paper of the Fish Subcommittee of the Upper Sacramento River Task Force, 12 pp.

Menchen, R. S., 1980. Estimated Fresh Water Sport Catch of Coleman Hatchery Yearling Steelhead in 1973. CDFG, Anadromous Fisheries Branch Office Report, November 1980, 6 pp.

Moffett, J. W., 1949. The First Four Years of King Salmon Maintenance Below Shasta Dam, Sacramento River, California. CDFG, 35(2), pp. 77-102.

National Marine Fisheries Service, 1971. Keswick Dam, A Report on the Present Condition of Keswick Dam Fish Trap and Recommendations to Improve Operations, December, 1971, 10 pp.

Needham, P. R., H. A. Hanson, and L. P. Parker, 1943. Supplementary Report on Investigation of Fish-Salvage Problems in Relation to Shasta Dam. U.S. Fish and Wildlife Service. Spec. Scien. Rept. No. 26, 50 pp.

Parisot, T. C., and J. Pelnar, 1962. An Interim Report on Sacramento River Chinook Disease: A Viruslike Disease of Chinook Salmon. Fish and Wildlife Service, Progressive Fish-Culturist Vol. 24, No. 2, pp. 51-55.

Ross, A. J., J. Pelnar, and R. R. Rucker, 1960. A Viruslike Disease of Chinook Salmon. American Fisheries Society, Transaction, Vol. 89, No. 2, pp. 160-163.

U.S. Bureau of Reclamation, 1985. Memo to CHAP Steeting Committee Members, from Program Manager, CHAP-USBR, Sacramento, September 10, 1985. Re: 1985 Status Report.

U.S. Bureau of Reclamation, 1971. Memo to RD, FWS, Portland, from RD, USBR, Sacramento, dated March 16, 1971, pertaining to Fish Trap Operation, Keswick Dam.

U.S. Fish and Wildlife Service, 1984. Coleman National Fish Hatchery Station Development Plan. Region I, USFWS. Prepared by the Division of Engineering, 64 pp.

U.S. Fish and Wildlife Service, 1982. Regional Resource Plan. Portland, OR pp. 534

U.S. Fish and Wildlife Service, 1981. Coleman National Fish Hatchery Operational Plan, 35 pp.

U.S. Fish and Wildlife Service, 1981. FY 1981 Annual Work Plan Advices. Fishery Assistance Office, Red Bluff, California, June 23, 1981, 18 pp.

U.S. Fish and Wildlife Service, 1980. Development of Methods of Control of IHN - A Virus Disease of Salmon (Concept Summary). Seattle National Fishery Research Center, 6 pp.

U.S. Fish and Wildlife Service, 1979a. Effect of Time and Size at Release on the Tendency of Chinook Salmon and Steelhead Trout Reared at Coleman NFH to Migrate Downstream and Adapt to Seawater. FAO, Red Bluff, CA, Progress Report, FY 1980 Annual Work Plan Advices, 3 pp.

U.S. Fish and Wildlife Service, 1979b. Proposal to Evaluate Time and Size at Release for Steelhead Trout and Four Races of Chinook Salmon Reared at Coleman NFH, California Fisheries Assistance Office, Red Bluff, CA, Office Report.

U.S. Fish and Wildlife Service, 1972. Memo to RD, USBR, Sacramento, from RD, FWS, Portland, dated March 24, 1972, pertaining to Fish Trap Operation, Keswick Dam.

U.S. Fish and Wildlife Service, 1971. Memo to RD, USBR, Sacramento, from the RD, FWS, Portland, dated February 19, 1971, pertaining to Fish Trap Operation, Keswick Dam.

U.S. Fish and Wildlife Service, 1986. Memo to Regional Director, FWS, Portland, from Field Supervisor, FWS, Sacramento. January 16, 1986. Re: USBR, CVFWMS Problem A-6, Coleman NFH-Whirling Disease.

U.S. Fish and Wildlife Service, 1963. Master Plan, Coleman National Fish Hatchery (Hatchery Development Plan), June, 1963, 54 pp.

U.S. Fish and Wildlife Service. Coleman NFH Annual Production Reports, 1943-1983. Inhouse Reports Issued Annually. Summarize Annual Fish Production and Operational Activities. Issued Each Calendar Year Prior to 1964 and Each Fiscal Year since 1965.

Appendix A

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

MEMORANDUM OF AGREEMENT BETWEEN THE
BUREAU OF RECLAMATION AND THE FISH AND WILDLIFE SERVICE

Pertaining to the custody and future operation of the Coleman Fish Hatchery and other fishery maintenance facilities of the Upper Sacramento River, Central Valley Project, California.

WHEREAS, the Bureau of Reclamation, hereinafter referred to the Bureau, has constructed, as a part of the Central Valley Project; fish trapping facilities below Shasta Dam; the Coleman Station fish hatchery; water supply and control houses for operating personnel; and other facilities for the protection and preservation of the migratory fish which spawned in the upper Sacramento River Basin prior to construction of the Shasta Dam; and

WHEREAS, the Fish and Wildlife Service, hereinafter referred to as the Service, has directed and conducted the operation of these facilities since their construction, with funds transferred to the Service from the Bureau; and

WHEREAS, the Bureau and the Service are agreed that as a result of the salmon maintenance program and the operation of Shasta Dam with a regard for the welfare of the fishery, the salmon runs above Shasta Dam appear to have become established below the dam in numbers equal to the numbers existing before the dam was built, and

WHEREAS, the Service has the authority and there is necessity for further investigation, protection, improvement, and conservation of fish in the Sacramento River Basin and for continued operation of Coleman Hatchery and related facilities, and

WHEREAS, the continued maintenance of the Sacramento River salmon runs is recognized as one of the purposes of the Central Valley Project in operating Shasta Dam, and

WHEREAS, the continuous release of not less than 2,500 cubic feet of water per second from Keswick Dam is considered to be the minimum flow necessary to maintain the fishery, and 3,500 cubic feet per second is considered the preferable low release, and

WHEREAS, water temperatures between 50° and 65° Fahrenheit are considered to be best suited to the welfare of the fishery.

NOW, THEREFORE, the Bureau and the Service, subject to approval of the Secretary of the Interior, do hereby mutually agree as follows:

1. That the current agreement "covering biological investigations for the salvage of migratory fish, and for the operation and maintenance of Coleman hatchery and holding ponds, and other facilities on the Sacramento River, Deer Creek, and Battle Creek, in the Central Valley Project, California" made and entered into as of the 30th day of June, 1947, between the Bureau and the Service, effective for the fiscal year ending June 30, 1948, and approved by Assistant Secretary of the interior William E. Warne on July 11, 1947, is extended to be effective for the fiscal year ending June 30, 1949.

2. That the Bureau, effective July 1, 1949, shall transfer, and the Service shall accept full custody, jurisdiction, and responsibility for the facilities described in Exhibit A attached hereto and made a part hereof, subject to restoration and supplementing of such facilities by the Bureau as follows:

    a. Repair and revision of the Coleman rearing ponds and water supply systems to satisfactory operating condition;

    b. The construction of adult fish holding ponds; and

    c. The alteration of the Coleman sewage disposal system to insure satisfactory operation.

3. That for the fiscal year 1950 and thereafter the Service will request funds by direct appropriation for operation of the Coleman hatchery and appurtenant facilities described in Exibit A.

4. That the Bureau shall retain responsibility for the facilities listed in Exhibit B attached hereto and made a part hereof, which facilities are a necessary part of the Sacramento River salmon maintenance program, and that the Bureau shall transfer funds annually to the Service in amounts mutually agreed upon as necessary for the operation of these facilities and for the necessary service and biological studies in connection therewith.

5. That in operating Shasta Dam, the Bureau shall make every effort to maintain flows and temperatures in the Sacramento River which are necessary for fishery maintenance, and shall consult with the Service when critical fishery conditions are anticipated.

The total cost of constructing the migratory fish control facilities was $2,013,750.52. The Bureau's cost of operating and maintaining the facilities, as of July 1, 1949, will have been $810,643.49. Under existing law, the total sum of 2,824,394.11 is included in the reimbursable costs of the Central Valley Project. However, it is agreed that in accordance with the policies set by the Act of August 14, 1946 (10 Stat. 1080), the total cost to the Bureau, as stated herein and as accuring from year to year, should at some future time be declared to be non-reimbursable.

This agreement shall become effective as previously stated herein and shall remain in force until otherwise directed by the Secretary of the Interior, or until legislation inconsistent herewith is enacted by Congress.

Bureau of Reclamation

By: /s/ G.E. Tomlinson
Acing Commissioner

Fish and Wildlife Service

By: /s/ Albert M. Day
Director

Attachments:

Exhibit A
Exhibit B

Approved: September 21, 1948

/s/ William E. Warne
Assistant Secretary of the Interior

I approve.

/s/ R.C. Price

APPENDIX B

BATTLE CREEK STREAM FLOW DATA

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Mean
1961	171	305	468	294	748	503	422	385	348	207	168	158	345
62	229	278	501	335	741	490	504	473	386	244	195	190	378
63	589	337	600	468	801	447	1081	758	461	305	242	245	525
64	295	438	311	445	336	318	380	375	317	220	188	205	319
65	221	419	1299	1144	635	529	894	633	506	346	292	276	600
66	276	395	335	403	448	441	515	432	295	237	210	216	349
67	222	448	574	788	548	640	717	964	785	448	281	261	556
68	275	276	349	730	912	632	451	396	308	242	250	252	421
69	264	342	792	1679	1151	734	906	1008	671	384	305	294	709
70	321	366	1041	2434	919	841	605	595	521	394	291	295	720
71	307	765	1017	864	556	741	693	744	641	405	291	287	610
72	296	339	410	411	508	734	529	462	380	271	238	276	404
73	362	467	548	960	939	833	653	750	448	314	236	246	561
74	327	1040	946	1808	700	1321	1108	811	679	545	396	358	838
75	392	423	462	458	963	850	729	851	739	438	325	283	573
76	363	397	405	350	400	491	441	386	297	252	253	254	357
77	250	255	242	269	260	266	231	266	223	201	191	207	238
78	205	262	463	1054	766	1110	982	656	514	371	248	240	570
79	221	263	259	345	708	557	483	663	367	254	230	234	380
80	318	415	583	1187	1072	768	542	584	449	339	247	248	561
81	272	259	368	523	535	593	476	388	292	222	210	218	362
82	322	1058	1063	791	502	879	1135	860	571	420	346	293	687
83	305	395	691	2485	1230	4903	1100	1220	1290	751	524	416	1276
84	420	440	911	868	636	676	599	651	597	436	328	343	575

Maximum of Record: 24,300 ft^3/s January 24, 1970

Minimum of Record: 52 ft^3/s August 8, 1962

Data collected by USGS, 1961-1984 Stream flow data.